The effects of internal and external trade liberalisation on agricultural growth: a case study of Vietnam

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THE EFFECTS OF INTERNAL AND EXTERNAL TRADE LIBERALISATION ON AGRICULTURAL GROWTH: A CASE STUDY OF VIETNAM

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Unless otherwise acknowledged, all of work presented in this thesis is my own work.

Che Tuong Nhu

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Abstract

In the last two decades significant economic reforms have taken place in what were once purely socialist economies. Most importantly, these economies have undergone a sweeping process of internal and external trade liberalisation by gradually moving towards a system of fully-functioning competitive markets. Along with this, there have been profound changes in institutional arrangements and, in particular, changes in property rights that allow for some form (in varying degrees) of private ownership and control. The results have been striking. Vietnam, for example, has experienced what many people may well regard as a miracle, or at least the beginning of one. From being a large importer of rice and other foodstuffs in the 1980's, Vietnam has now become the third largest exporter of rice in the world, all without a significant increase in capital or labour inputs and with virtually no technological change.

This dissertation focuses directly on the effects of this trade liberalisation. It provides a theoretical and empirical analysis which explains the increases in both rice output and its growth in terms of the incentive effects that result from changes in property rights and market structures. It argues that private ownership and control of property and competitive pricing and market structures induce individuals to work harder and use land more efficiently.

The theoretical analysis contains both a static and a dynamic model of the effects of internal and external trade liberalisation on agricultural growth. In the static model land and labour are measured in terms of efficiency units which include the optimal choice of effort in both work and the exploitation of land, thus incorporating incentive effects, whereas changes in the definition of the profit function measure changes in market structures that accompany economic reform. The derived form of the institutional production function and the resulting comparative statics effects show that total factor productivity, the optimal choice of effort, and rice output increase directly with the extent of trade liberalisation.

The empirical analysis considers the specific case of rice production in Vietnam as an application of the theoretical models. Given estimated results for the share parameters of labour, land, current inputs, and capital in the rice production function we show that the growth in factor productivity that results from changes in market structure and incentive effects is the most important explanatory factor for the increase in rice production, and that each new stage of trade liberalisation results in new and higher steady-state values for rice output. Indeed, based upon a construction of the timescale for the system to reach a vicinity of the steady state, it is shown that even with an assumed zero rate of growth in the 'Solow residual' component of total factor productivity that trade liberalisation alone may increase the production of rice by an order of two or three times its initial value. Competition, changes in market structures and property rights, along with the enhanced incentives that go with it, matter most.

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Acronyms

CCP	Congress of Communist Party
CM	Council of Ministers
CMEA	Council for Mutual Economic Assistance
COD	Country Operation Division
CPC	Central Price Committee
CPP	Communist Party Politburo
CPS	Communist Party Secretariat
CPV	Communist Party of Vietnam
CRD	The Cuu Long River Delta
DGS	Department of General Statistics
EAPR	East Asia and Pacific Region
FAO	Food and Agriculture Organisation
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GSO	General Statistics Office of Vietnam
GVAP	Gross Value of Agricultural Product
Ha	Hectare
Kg	Kilogram
Km	Kilometre

LDCs	Less Developed Countries
MAFI	Ministry of Agriculture and Food Processing Industry
MIT	Ministry of Trade
MPI	Ministry of Planning and Investment
MWR	Ministry of Water Resources
NICs	Newly Developed Countries
NIRR	National Investigation of Rural Region
NIRRA	National Investigation of Rural Region and Agriculture
RRD	Red River Delta
SBV	State Bank of Vietnam
SDAFF	Statistics Department of Agriculture, Forestry and Fishery
SDP	State Department of Price
SNA	Statistics National Accounts
SPC	State Planning Committee
SRF	Survey of Rice Farmers
UNDP	United Nations Development Program
WB	World Bank

Part One

The nature of internal and external trade liberalisation in transitional economies

Chapter 1

INTRODUCTION

As a result of economic reforms in some transitional agrarian economies there has been a significant increase in agricultural production. In this regard, Vietnam has experienced what many people may well regard as a miracle, or at least the beginning of one. From being a large importer of rice and other foodstuffs in the 1980's, Vietnam has now become the third largest exporter of rice in the world, all without a significant increase in capital or labour inputs and with virtually no technological change. In fact, output in the agricultural sector as whole literally doubled from 1981 to 1993 (General Statistics Office of Vietnam, GSO, various years).[1] This dissertation is concerned with this striking phenomenon, in particular, and how economic reform has affected economic growth and efficiency in transitional economies in general. It constructs and empirically tests a model (a static version and its dynamic counterpart) which explains the increases in rice output and the effects on growth as a result of the enhanced

[1] In China the comparable figure for the period 1978 to 1984 is 61 percent (Lin, 1991).

incentives to work hard and use land more efficiently. The vehicle which allows for these incentive effects to take place and to have such an impact is the institutional change, including relevant changes in market structure, associated with internal and external trade liberalisation.

This chapter is organised as follows. Section 1.1 defines the concepts of internal and external trade liberalisation as used in this dissertation. In order to provide an overall context for the models that follow, Section 1.2 provides an archetypical characterisation of the transitional periods involved in moving from a Soviet-type command economy to a fully-functioning market economy. Section 1.3, finally, gives an overview or the plan of the rest of the dissertation.

1.1 The concept of internal and external trade liberalisation in transitional economies

In the simplest terms, internal trade liberalisation in transitional economies is the process of the 'freeing-up' of the domestic market. In terms of its implications for producers and consumers, that process includes three main components: the freedom to purchase and sell goods rather than having them allocated and their use regulated through a state administration; the removal of price controls and other interventions by the government thus allowing prices to reflect their 'real' or market value rather than a state-planned and often compulsory low price; and the removal of barriers to market entry so that competition between different firms and industries becomes possible.

Internal trade liberalisation is important for creating a fully-functioning market economy but it is not of course synonymous with the 'opening up' of the international market. External trade liberalisation in transitional economies not only means the lowering of domestic trade restrictions as is normal in market economies,[2] but it also includes the following: the decentralisation of the government trade monopoly and the creation of a competitive environment among trade organisations; the freedom to purchase and sell all goods on the international market, via (for example) private trade organisations; and the removal of all trade barriers to international markets. Besides this, external trade liberalisation requires the imposition of necessary reforms in exchange rate policy. These include the unification of multiple exchange rates (into a single market rate) and the achievement of an appropriate exchange rate which reflects more closely the 'real' true value of domestic currency.

Moreover, internal and external trade liberalisation must also be accompanied by key changes in the institutional framework, ones that allow the farmer to become the sole decision-maker in the productive unit. The process of changing property rights and the move toward complete privatisation is the central feature of this general institutional change.

1.2 Moving from a Soviet-type command economy to a functioning market economy: transitional periods

Although the specific form of economic liberalisation may vary between different transitional economies, certain steps, according to Perkins (1994), must be taken if the system is to evolve into a fully-functioning market economy. First, the economy must achieve macro stability, meaning an acceptable level of inflation and a financially stable

[2] It is noted that although international trade negotiations have succeeded in reducing tariffs to very low levels, national governments can still resort to intricate policies to protect their domestic industries from foreign competition (see Vousden, 1992, p.xi).

international balance of payments.[3] Second, inputs and outputs must be available for private purchase and sale on the market, rather than being allocated administratively through a state bureaucracy. Third, prices must reflect real market-values rather than an imposed or planned price. Fourth, barriers to market entry must be removed so that competition between different localities and firms is possible. Finally, key changes in the institutional framework must be established and enforced so that decision-makers have an incentive to maximise profits and cut costs (Perkins, 1994). In addition, in rural areas, there must be a de-collectivisation of rural society and a gradual freeing-up of domestic markets through trade liberalisation (both internal and external) of agricultural commodities, combined with the privatisation of property rights.

For our purposes, the main transitional periods in agriculture begin with the cooperative or communal system, proceeding through a period of de-collectivisation in rural society and finally with a move toward the eventual freeing up of internal and external markets. The exact sequence in that process is not necessarily the same in different countries (McKinnon, 1993). For example, in China the process of de-collectivisation and internal trade liberalisation happened more or less simultaneously (Perkins, 1994). However, in Vietnam, de-collectivisation started in 1981, but the process of internal and external trade liberalisation did not begin until eight years later (Fforde and Vylder, 1996). In Russia, de-collectivisation began in 1988, but the process of internal trade liberalisation is still far from completed (Murphy, Shleifer and Vishny, 1992). Nevertheless, there are still some central characteristics that can be attached to these transitional periods, ones that apply to all transitional economies. They are

[3] Some argue that the transitional economy can still achieve a fully-functioning market economy without the condition of macro stability (see, for example, Fforde and Vylder, 1996).

described as follows.[4]

(a) The cooperative-communal era

A crucial principle of Soviet command type economies is that the State must strictly control all commercial activities. The strict control of domestic commerce means that the State regulates all rights of purchase and sale through an administrative system at a low planned and compulsory price. This results in a complete absence of domestic markets for both goods and factors in the cooperative-communal era. Further, the strict control of foreign trade means that external trade is only carried out by a few state trading monopolies under a planned exchange rate regime, one which does not reflect the 'real' or true value of the domestic currency. For a long time, the former Council for Mutual Economic Assistance (CMEA) controlled the majority of trade activities among many former socialist countries through Trade Agreements, in which the exchange rate was decided by agreement and did not reflect the real value between exported and imported goods. Overvalued, multiple exchange rates and trade subsidies were popular and caused domestic prices to be isolated from changes in world prices (Murphy, Shleifer and Vishny, 1992, and Perkins, 1994).

This period of the cooperative-communal era is also characterised by the compulsory state-acquisition of agricultural production, and collective property rights. The communal form of agricultural production causes problems due its compulsory rather than its voluntary nature. In the usual context, through its accompanying economies of scale, the cooperative (potentially) can provide gains over the small and

[4] The particular sequence (and the characteristics) of the transitional periods for the case of Vietnam is discussed in Chapter 2 below.

fragmented family farms in the form of: (i) risk sharing, especially in primitive agriculture, which is highly dependent on such exogenous variables as the weather and pests; (ii) the capacity to improve backward technology, poor infrastructure and poor irrigation systems; and (iii) the improvement in the allocation of resources such as labour, draft animals and farm tools according to peak-load problems in the farming year or across various regions or farms themselves.

Nevertheless, a main problem with the commune, one which stems from the compulsory characteristics of the cooperative form, relates to the absence of the right to withdraw from the collective. Indeed, according to Lin (1990), the absence of the right to withdraw has a significant impact on the incentive structure within the collective. When there is freedom to exit, the members of the collective can decide at the end of each production round whether or not they will continue to participate in the next round. Those who find that they are better off being members of the collective will retain their membership, otherwise, they will withdraw from the collective. The compulsory nature of the cooperative reduces the motivation for efficient operation and often eliminates the gains from any economies of scale in the second and subsequent rounds. It eliminates the motivation for efficient outcomes and a fair distribution income by management.

In any case, to make a collective into an efficient institution also requires an effective means of supervision, and this is often impractical if not impossible. A self-enforcing agreement among collective members in which each one promises to provide as much effort as possible on their household farm is perhaps an effective alternative when supervision is too costly (Telser, 1980), but this obviously may still result in problems such as waste and shirking. Moreover, income distribution in the cooperative is solely based on the counting of work points rather than on efficiency criteria, and since household endowments vary, it is clear that some well-endowed households will be hurt by a work-point system and the elimination of any dividend payments (Chinn, 1980).

Finally, as a matter of both principle and practice in the collective-communal system, the State absolutely controls the property rights to land, and all other important assets in agriculture. The sole 'landlord' (the State), through centralised management and a strict planning-bureaucracy, controls all output targets and operations as well as the choice of investment for production. In this system of production, the farmer's role is only that of a 'mandatory worker', so to speak. As such, there are no clear incentives for the farmer to work harder or to exploit the available natural resources more efficiently. The State also controls the sale and allocation of all outputs and inputs through a state commercial network, and with it determines the prices of all inputs and outputs. A network of commercial cooperatives, which are owned by the State, provides the necessities and indeed that network virtually ensures a scarcity of consumer goods for farmers. Because there is a total absence of both domestic and international markets for agricultural goods the State administratively allocates inputs and outputs, via a state bureaucracy, with compulsory prices set at arbitrarily low levels. All available studies of this period are uniform in their criticism: the cooperative-communal period results in an agricultural industry that is characterised by low productivity and large inefficiency (for the case of China see (Lin, 1990), for Vietnam (Pham N Cuong, 1991) and for Eastern Europe, see (Brada, 1986)).

(b) The de-collectivisation of rural society

This period provides a first step or move towards the privatisation of property rights, but generally speaking a market for the sale or exchange of land is not yet established. De-collectivisation not only provides more freedom over property rights, product choices, and investment decisions made by producers but also entails the removal of barriers imposed by centralised management and the planning bureaucracy. In this period, the farmer's role becomes that of a partial decision-maker in the system of production.

Even though input and output markets do not fully exist yet, in that the State still controls or administers the allocation of inputs and outputs through a state bureaucracy at planned state prices, the farmer is granted the conditional right to control the sale of output so that he or she may opt (to some predetermined limit) not to sell goods at the State price. Consequently, the State may stipulate a higher state price in response, with free markets emerging (albeit to a limited extent) to absorb any residual output at a free market price. The farmer, in other words, cannot fully exercise the role of decision-maker because he (or she) can still not sell the entire output produced at domestic market-clearing prices or freely purchase factors of production in a market context. Therefore the incentive for farmers to work hard and exploit natural resources efficiently exists, but they are severely limited.

(c) Internal trade liberalisation in agriculture

In this transitional period, the system of domestic markets for agriculture is established so inputs and outputs are available for private purchase and sale on the market, at a 'real' or 'fair' market price. The removal of barriers to market entry provides full freedom of commerce in agricultural goods on domestic markets, and the full freedom of product choice and investment. The agricultural price for inputs and outputs (typically) increases to a true domestic market price and hence leads to more incentives for farmers as decision-makers to exploit labour and natural resources more efficiently. In this period, the farmer can exercise his or her full rights as a decision-maker and as a partial landlord. However, without external trade liberalisation the international market is not yet open, or rather it is governed by a strict state monopoly over international trade at an imposed exchange rate. The domestic price still does not reflect the world price due to the presence of multiple exchange rates (for different types of transactions) and trade subsidies.

(d) External trade liberalisation in agriculture

This period implies the complete (or near complete) decentralisation of the state monopoly on foreign trade, and lower trade restrictions and open competition among private trade organisations. It also entails reforms in exchange rate policy, e.g., a switch from a fixed to a free or flexible exchange rate regime. Under trade liberalisation the prices of agricultural goods converge toward world prices. Because the market for agricultural goods is widened, the decision over product choice and investment by farmers is greater so that they now respond to incentives more fully and produce more efficiently.

Indeed, with both internal and external trade liberalisation, along with changes in property rights, the farmer's role in production changes from that of a sole worker to the triple role of worker, manager and landlord. This means that the farmer can now have three (joint) behavioural responses: as worker, economic decision-maker, and profit maximiser. The new roles for the farmer motivates (or gives incentives to) the individual to provide more effort, to increase the utilisation of natural resources (especially land), and to use current inputs such as fertiliser and pesticides more efficiently. The farmer can only exercise the rights of decision maker and profit maximiser if the domestic markets for agricultural inputs and outputs exist. These rights can be broadened if international markets for agriculture are available.

1.3 The plan of the dissertation

A general overview of the dissertation is as follows: Part One (Chapters 1 and 2) sets out the main argument of the dissertation and discusses the general characteristics of trade liberalisation in transitional economies. Part Two (Chapters 3, 4 and 5) provides a detailed static model, the comparative statics effects, and a dynamic model of the effects of trade liberalisation on agricultural output and growth. Part Three (Chapters 6, 7 and 8) applies and tests the models for the case of Vietnam. Chapter 9 gives some concluding remarks to the dissertation as a whole, and all of the various and extensive data sources and adjustments are compiled in the Data Appendix.

In more detail, Chapter 2 (with the general discussion of Chapter 1 in mind), fully describes the relevant transitional periods and the process of trade liberalisation in the specific case of Vietnam. It begins with an overview of agriculture in Vietnam, and includes a series of descriptive statistics that detail the dramatic increases in agricultural output that occurred with economic reform. The precise institutional arrangements between the State, the cooperative, farm households, and the connecting markets and market structures in the various transitional periods are described in detail.

Chapter 3 constructs a static model of the effects of trade liberalisation on agricultural output. A key concept in this chapter is the notion of an 'institutional' production function; one which reflects not only the usual technical relationship between inputs and outputs, but also incorporates the farmers' response to the institutional and market arrangements within which they work. Effective labour and land is measured in terms of efficiency units in order to include the optimal choice of effort in both work and the exploitation of land, thus capturing the incentive effects that result from economic reform. With this, and the construction of an appropriate profit function, total factor productivity and the optimal choice of effort in the 'institutional' production function depend both on the price level and the structure of the goods and factor markets, allowing the effects of trade liberalisation (in theory) to be clearly seen. Based on this work, Chapter 4 provides a theoretical analysis of the comparative statics effects of internal and external trade liberalisation. The relevant effects are captured in terms of changes in both average goods prices and factor prices in various transitional periods. The growth in total factor productivity and changes in the optimal choice of effort with economic reform are also carefully analysed.

Chapter 5 presents a dynamic model of the effects of internal and external trade liberalisation in agricultural growth. The static model of Chapters 3 and 4 is now extended to account for long-run effects, given the farmer's optimal intertemporal choices regarding effort, consumption, and investment, and the constraint of a profit function that incorporates different market arrangements that result from trade liberalisation. The basic idea is to analyse the resulting optimal transitional paths and the new steady-state outcomes that are the result of the enhanced incentives to produce more, and more efficiently, in transitional economies. A comparison to a comparable growth model without incentive effects highlights the importance of the incentive effects (in terms of resulting changes in output, consumption, and so on) contained in the form of the 'institutional' production function.

Chapter 6 is the first in a series of three empirical chapters. It begins with a detailed overview of rice production and the performance of the rice industry in Vietnam. In Vietnam, rice is not only the most significant source of nutrition for the Vietnamese people, it is also the major source of export revenue and, because of this, economic reform has impacted most on this sector. Based upon the models developed in Part Two, this chapter also provides an econometric estimation (needed later) of the share parameters of inputs in an 'institutional' form of a rice production function. The comparable measures for a 'technical' production function are also obtained.

Given the static model of Chapters 3 and 4, Chapter 7 provides an extensive quantitative analysis of the effects of internal and external trade liberalisation on rice production in Vietnam from 1976 to 1994. In terms of the 'institutional' production function we distinguish between two main reasons for the dramatic increases in rice output: the growth of factor inputs and the growth of total factor productivity. The latter, in turn, is decomposed into a growth rate in total factor productivity that results solely from the effects of internal and external trade liberalisation, and one that is a result of a host of items or 'unexplained residuals'. Across all transitional periods we show that the growth in factor productivity that results from internal and external trade liberalisation is the most important explanatory factor for the increase in rice production. The incentive effects and the changes in market structure that accompany economic reform matter most.

Chapter 8, finally, provides an empirical analysis of the transitional paths and the long-run steady-state values of capital and output for rice production in Vietnam. It is based on the dynamic model in Chapter 5. After a suggestive look at the data, we first compute the long-run levels of the capital stock for rice production in Vietnam in the various stages of trade liberalisation. Using these figures, we then calculate the speed of convergence or the timescale required for the rice industry to attain the 'vicinity' of a steady-state in each transitional stage and thus, combining the two steps, determine the steady-state levels for rice output in the period of output contracts compared to that of the 'freeing up' of domestic and international markets. We show (in a way fully consistent with the theoretical model of Chapter 5) that each new stage of trade liberalisation results in a new and higher steady-state value for physical capital and rice output, and that economic reform alone may have increased rice production by an order of two or three times the initial level given in the communal system. The positive effects of trade liberalisation are also seen through an analysis of the predicted transitional growth rates of rice output in the different stages of trade liberalisation, with the growth rate in the period of full-trade liberalisation shown to be much higher than that in the period of partial-trade liberalisation.

Chapter 2

THE PROCESS OF ECONOMIC LIBERALISATION IN THE RURAL AREAS OF VIETNAM

With the general nature of internal and external market liberalisation outlined in Chapter 1 in mind, this chapter focuses on the case of Vietnam. As mentioned, Vietnam is an agrarian economy where agriculture clearly plays a major role and, as the result of sweeping economic reform, Vietnam has achieved remarkable success in increasing the output of rice and other food products. The idea here is simply to provide an overview of Vietnamese agriculture and a brief chronological account of the stages which have led to this remarkable success, with an eye to the theoretical and empirical analysis that is to follow in later chapters. Section 2.1 gives an overview of agriculture as an industry in Vietnam and provides some preliminary data on the growth of agricultural production and rice in particular. Section 2.2 classifies and describes the various transitional periods (toward fully free markets) experienced in the case of Vietnam, with a careful description at each step of the institutional framework that prevailed. Section 2.3 concludes.

2.1 Overview of agriculture in Vietnam

Located in South East Asia, Vietnam is long and narrow, with 33.1 million hectares in total area and a highly dense population of 74 million people (GSO, 1996). Indeed, the population density on agricultural land is 980 people per kilometre squared, and the population continues to expand at a rate of 2 per cent annually (GSO, 1996). Nevertheless, the tropical climate, with its high humidity and fertile lands, provides a natural advantage for agriculture, especially rice production, where the two large deltas of the Red and Cuu Long rivers are the dominant rice-supplying regions of the country. These two deltas contain most of the population and are situated over 1,000 kilometres apart in the north and south[1]. There is also a small and narrow delta in the centre of the country, quite suitable for agricultural production. Even though humid and tropical weather dominates the entire country, there are some differences between the north and south. The monsoon-influenced north has four different or distinct seasons, while for the most part the rainy season dominates the weather in the south, with occasional dry spells.

Vietnam is an agrarian economy with about 80.2 per cent of the population living in rural areas (GSO, 1996). The agricultural sector[2], which accounts for roughly

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[1] The division of the 'north' and 'south regions is based on the natural conditions of geography and process of liberalisation. The 'north' includes the provinces of the North Mountain and Midlands, Red River Delta and North Central Coast. The south includes the Central Highlands, east of the South and Cuu Long River Delta.

[2] According to the System of National Accounts (SNA) this includes crop cultivation, animal husbandry, and agriculture, but excludes fisheries and agro-processing.

50 per cent of material or non-service output and 30 per cent of Gross Domestic Product (GDP)[3] provides jobs for 72.3 percent of the labour force of the country (GSO, 1995). Cultivated agriculture is predominant (about 74 percent of gross agricultural output (GSO, various years)), especially rice production which constitutes ninety per cent of the output of food grains. As the most important industry in agriculture, any change in rice production obviously causes a major change in agricultural output.

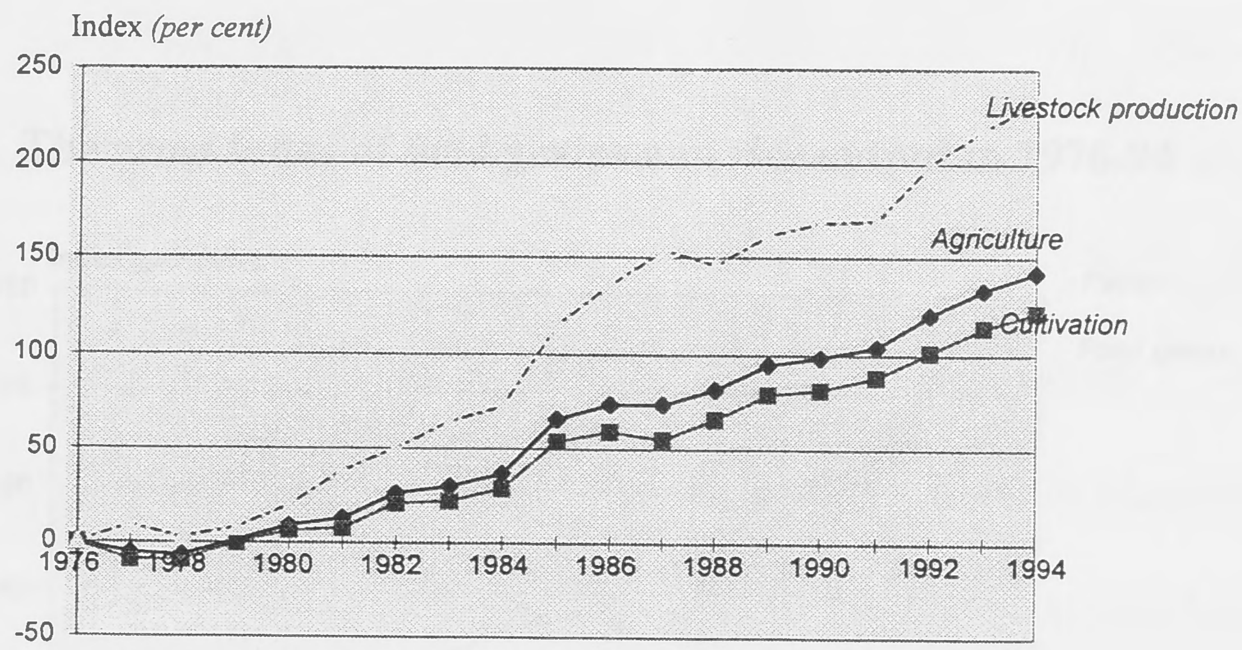
The growth of agriculture, which includes cultivation and livestock production, since reunification (1976 to 1994) is indicated in Figure 2.1 (using the output of 1976 as a base figure). During the height of the collective system, the years 1976-80, the growth of agriculture, cultivation and livestock had decreased sharply. Since the first stage of economic reform in agriculture (beginning in 1981), until now, growth has increased steadily over time. The average gross index (1976=100) is 168.6 per cent, 156.3 per cent and 221.7 percent for agriculture, cultivation and livestock respectively (Statistics Department of Agriculture, Forestry and Fishery-SDAFF, GSO, various years). In other words, after more than a decade of economic reform, the output in 1994 is more than double that of 1976 for agriculture as a whole, cultivation and livestock respectively (SDAFF, GSO).

During the process of economic reform, agricultural output has increased rapidly in terms of both cultivation and the size of the livestock industry, but the structure of agriculture has also changed with a relatively smaller predominance of cultivation generally. That tendency can be observed by the gross share of cultivation in agriculture

[3] There are some arguments that the actual share of agriculture in GDP is higher than the data show because the share of the service sector in GDP may be lower than 41.7 per cent, as reported (GSO, 1994). In fact, the reported data for the service sector (the new Statics National Account or SNA, applied since 1993) makes the share of the service sector in Vietnam similar to that in some New Developed Countries (NICs)!

decreasing from 80 per cent in the 1980's to about 74 percent in the 1990's (SDAFF, GSO, various years).

Figure 2.1: **The gross index of agriculture, cultivation and livestock production in 1976-94 (*at 1989 prices*)**

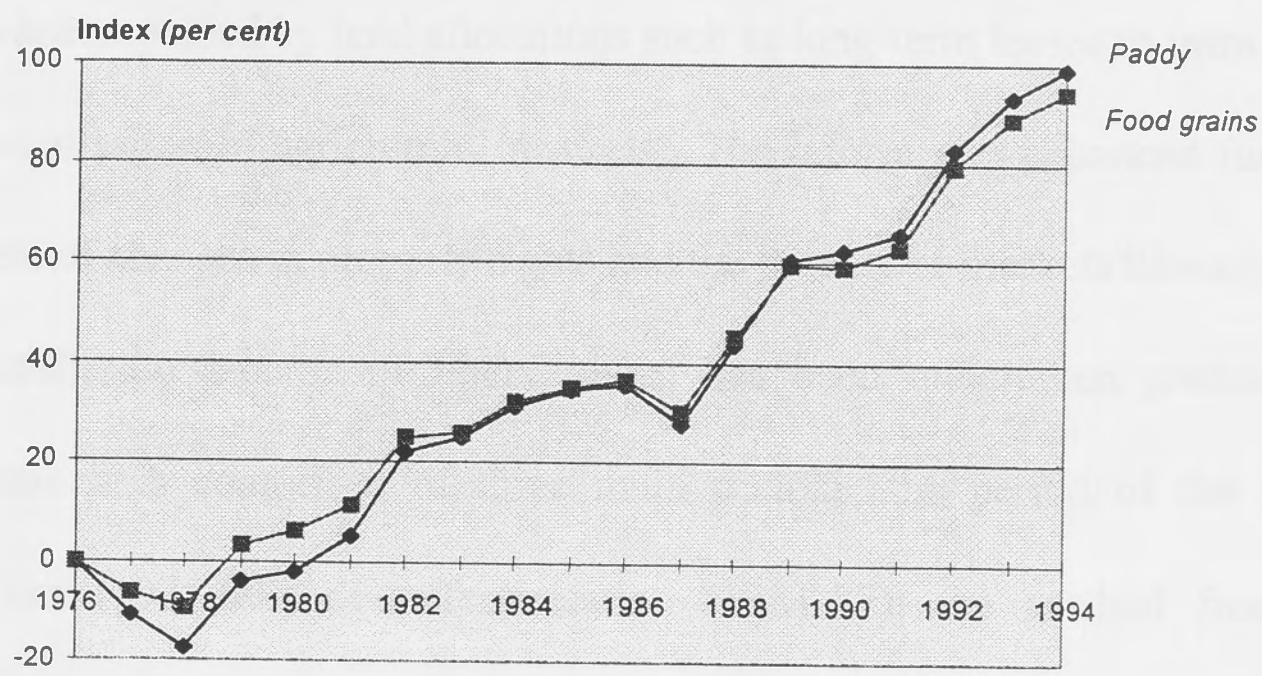


Sources: *The Statistics Department of Agriculture, Forestry and Fishing (SDAFF)- General Statistics Office (GSO)*

Such diversification was also a notable feature of cultivation's structure. The rapid development of internal and external markets, and the added demands for new products that resulted, encouraged and enhanced the development of a variety of fruit and industrial crops, and in so doing more efficiently exploited the specific natural advantages of every region. However, as the major player in agriculture, the outstanding success of the industry as a whole is still explained by the extremely high growth rates of rice production.

The growth of food grains and rice production (measured in terms of thousands tons of rice equivalent) over the period 1976-94 is illustrated in Figure 2.2. The decreased trend in the period 1977-80 and the dramatic boost since 1981 until the present for food grains and rice production are notable features of this graph. From being a major food importer, Vietnam quickly met its internal demand for food stuffs and indeed soon became the third largest rice exporter in the world.

Figure 2.2: **The gross index of food grains and rice output in 1976-94**



Sources: *The Statistics Department of Agriculture, Forestry and Fishing (SDAFF)-General Statistics Office (GSO)*

2.2 The process of economic liberalisation in rural areas

In the face of poor economic performance in the early 1980's, and despite large amounts of Soviet assistance, the shortcomings of the socialist system characterised by central planning, administrative direction, rapid industrialisation and the expansion of state sector management came to be recognised. The prospect of declining Soviet aid added to the push for dramatic reform in the structure of the Vietnamese economy. In 1981, under the pressure of a serious food shortage, the State had to partially give up its collective strategy and began a process of a partial de-collectivisation in agriculture, specifically by introducing the product contract system (Communist Party Secretariat, CPS, Order 100, 1981). Further, in April 1988, the fundamental reforms known as the renovation program *(doi moi)* were charted by a Politburo or Council of Ministers resolution (Communist Party Politburo, CPP, Order No 10). The product contract system in agriculture was improved and strengthened by the household contract system, which was accompanied by land allocations such as long-term leases to farm households and the liberalisation of agricultural markets. The reform was enhanced further by the development of changes in property rights and the process of markets liberalisation.

Overall, the process of liberalisation has been undertaken gradually and in general terms it is comprised of three main periods: the period of the communal-collective era (1975-80); de-collectivisation (1981-87); the gradual freeing up of domestic markets for agricultural goods; and external trade liberalisation (1988-89 until the present).

(a) The compulsory collective regime in the state planned economy (1975-80)

Soon after the reunification of Vietnam (1975), the State launched and strongly pursued the campaign of collectivisation for agriculture in the south (Communist Party of Vietnam, CPV, Order 24, 1975).[4] At that time, the system of the compulsory cooperative was already established in the north for nearly two decades, or since 1958

[4]The independent farming family farm was predominant in Vietnam for thousands of years before the socialist regime was established in the North in 1954. Since 1958 the cooperative has been the basic collective economic unit, to which most central and north Vietnamese farmers belong (Chu V Lam, *et.al.* 1992, p.13).

(Chu V Lam, Nguyen T Nguyen, Phung H Phu, Tran Q Toan and Dang T Xuong, (1992, p.13) and Nguyen S Cuc (1995b, p.18). In fact, generally speaking, the compulsory collective regime (in the north and south) had control over all agricultural activities in Vietnam during the period 1976-80, and certainly so by 1980. However, there were clear differences in the level and content of the collective system between the north and south.

During the wartime or before reunification, the cooperative in North Vietnam developed from a pure production unit into a social, economic and quasi-political entity (Fforde and Vylder, 1996). Again, generally speaking, the development of compulsory collectivisation in the north experienced four forms: the 'production collective' (*Tap doan san xuat*); the 'exchange production group' (*To doi cong)*; the 'low advanced cooperative' (*Hop tac xa bac thap*) and the 'advanced cooperative' (*Hop tac xa bac cao*).

The 'production collective' was a primitive form of cooperative, in which 20-30 neighbouring households combined their assets but still controlled ownership over their land. Incomes were paid in proportion to the assets contributed by each member. The 'exchange production group' was the next step towards collectivisation, in which a group of households was involved in the exchange of labour, farm tools and draft animals. In the 'low advanced cooperative', households in one or two neighbouring villages combined their land, draft animals, farm tools and other assets. In the 'advanced cooperative', all means of production were collectivised across several villages, or one commune.

In 1975, the low advanced and advanced cooperatives were dominant in North

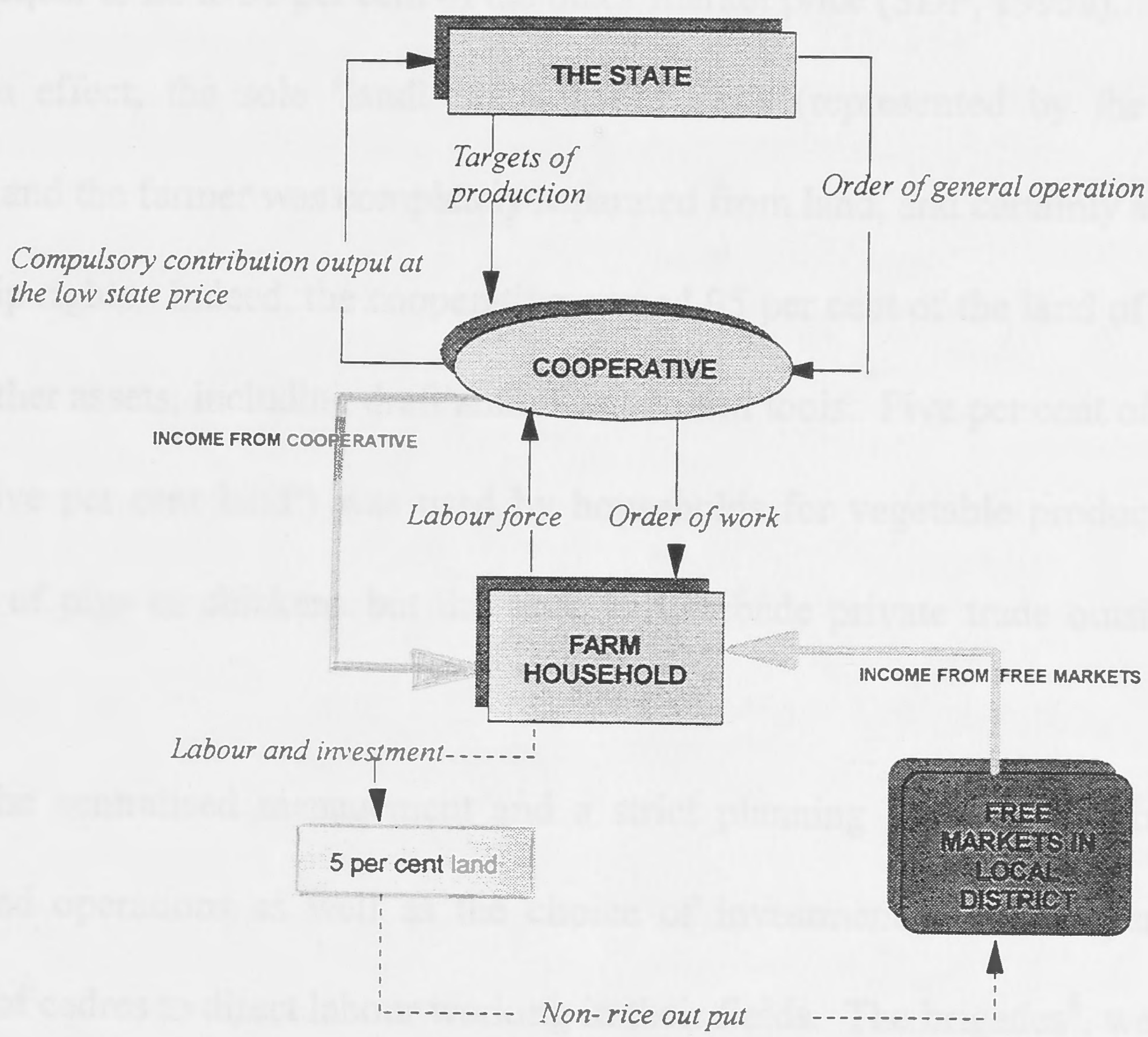
Vietnam. At that time, 97 per cent of farmers had joined cooperatives, with 88 per cent of cooperatives being advanced cooperatives. In 1979 (prior to economic reform), there were 4,154 advanced cooperatives at the commune size (Chu V Lam, *et. al.* (1992), p.39).

The agricultural collective system in the south was different from that in the north because of the specific characteristics for agricultural production in the south. First, there was a strong peasant middle class comprising about 70 per cent of all farmers and controlling about 80 per cent of the cultivated land (Chu V Lam, *et. al.* (1992), p.42). Secondly, the south had more advanced technology and more mature markets for agricultural commodities, all of which had been established before unification. In fact, a Soviet command-economy style of cooperative could basically not operate well in the south. Farmers in the south were much more experienced and comfortable with the operation of a market economy, and so were reluctant to adopt or implement any reasonable (not less unreasonable) commands from the State.

In 1976-80, the form of the 'production collective' was popular in the south and dominant in the Cuu Long River Delta (CRD). At the end of 1980, in the south, there were 1,518 cooperatives and 9,350 'production collectives', involving 36 per cent of farmers in the south and 70 to 90 per cent of farmers in the centre region of the south of Vietnam (Chu V Lam, *et. al.* (1992), p.46). These 'production collectives' controlled nearly 95 per cent of the area available for cultivation (GSO various years).

Basically, in rural areas of Vietnam, the administrative state system was comprised of four levels: the government, the province, the district, and the commune. In this period, on behalf of the State, the administrative system managed all of the activities in the cooperatives and controlled the entire range of activities of farmers. In terms of agricultural production, the farmer could not even decide the number or composition of his or her own labour force (Pham N Cuong, 1991, p.15). Given the differences between the types of collective in the north and south, the approximate relationship among the State, the cooperative,[5] the household or farmer and the free market in each local district is indicated in Figure 2.3.

Figure 2.3: **The relationship among the State, cooperative, farm household and the free market**



Based on the state plan for the agricultural sector, the State Planning Committee (SPC) set production targets and plans, including the kinds of crop to be grown in each

[5] For simplification I use the term 'cooperative' to mean both the low advanced and advanced cooperative (popular in the north) and the 'production collective' (popular in the south).

province, and provided guarantees of inputs to be supplied, such as fertiliser, chemicals and insecticide. The province detailed a sub-plan for each district, and the districts directly managed production for large advanced cooperatives while the commune managed small scale cooperatives (Che V Tan, 1982).

After submitting to the State a quantity of rice (as a kind of tax), the remaining rice was divided by the number of work points earned by the farmers, where 10 points were equivalent to one working day. If an average dividend payment (in terms of rice equivalents) for one work point exceeded the maximum allowed, then the cooperative had to sell the excess rice to the State at the state price. That price was very low, perhaps equal to 20 to 30 per cent of the black market price (SDP, 1995a).

In effect, the sole 'landlord' was the State (represented by the cooperative system), and the farmer was completely separated from land, and certainly so in terms of ownership rights. Indeed, the cooperative owned 95 per cent of the land of its members and all other assets, including draft animals and farm tools. Five per cent of land (the so called "five per cent land") was used by households for vegetable production and the breeding of pigs or chickens but the state still forbade private trade outside the local district.

The centralised management and a strict planning bureaucracy controlled the targets and operations as well as the choice of investment. The cooperatives used brigades of cadres to direct labour working in their fields. The brigades[6], were given the target plan by the cooperatives and were meant to deliver all output to the cooperative. The system relied upon a detailed framework of labour categorisation and norms in

[6] Brigade cadres were meant to control directly a labour force of over 100 farmers which turned out to be very difficult for the lowly educated peasant.

order to decide upon the inputs that would be needed to meet the output target, and also to calculate labour remuneration. Once again, remuneration in a cooperative was based solely on the labour contribution and took the form of work points. The income of a household depended on the number of work points earned by the family members and the average value of a work point. Because the farmer's income depends on the man-days worked or work points, which were determined by inefficient and bureaucratic managerial staff, the actual distribution of income often turned out to be egalitarian. In this system the farmer was acted as a 'mandatory worker' and incentives to work hard or to exploit the available natural resources efficiently were absent.

Not surprisingly, for the farm households, the "five per cent land" was the main source of income. They invested labour and resources to increase output from that land in particular. In fact, the output from the "five per cent land" was seen as compensation for food shortages because the payment in terms of rice from the cooperative was often not sufficient for survival. The residual product from the "five per cent land" (except for rice and other key agricultural goods) was permitted to be sold in the local market at the market price. Even though small markets still existed in rural areas, the State absolutely controlled all marketing of rice. Legally, farmers could not sell rice or pigs or other key agricultural goods in the local district.

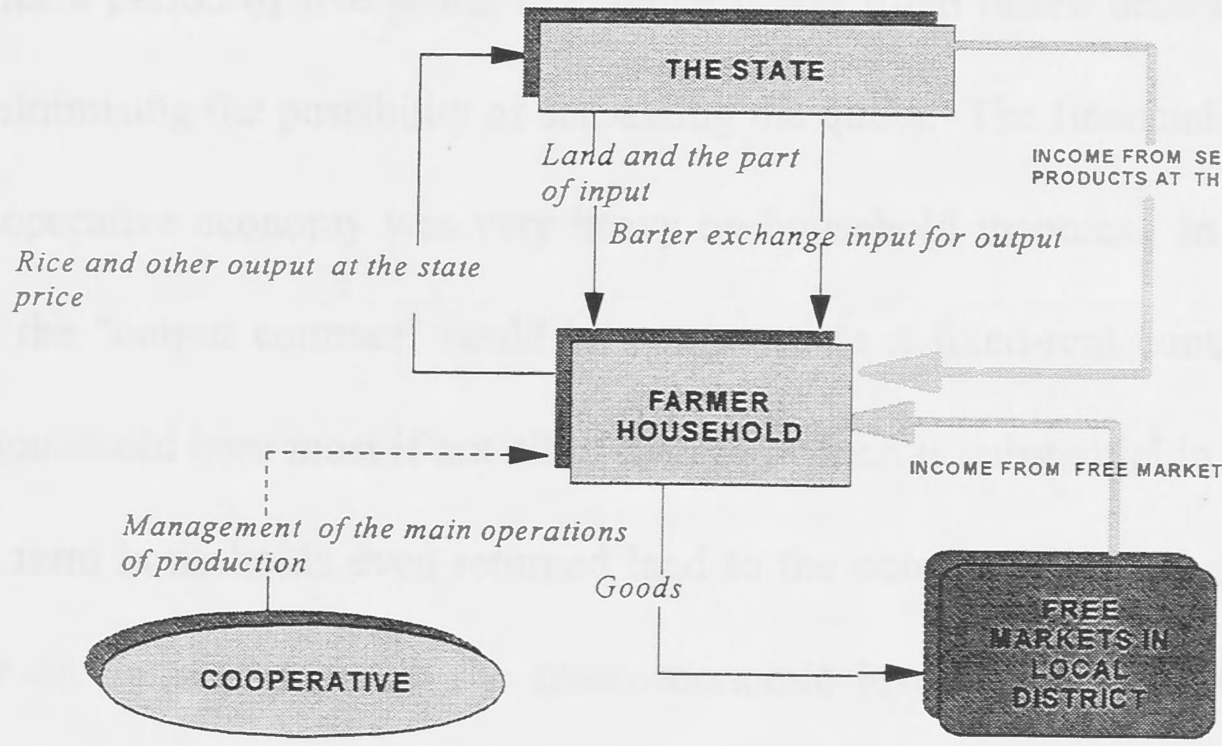
Needless to say, there was a total absence of both domestic and international markets for agricultural goods in this period. The State was a monopsony purchaser of all output and supplied all main materials through the state commercial network. More over, the state strictly regulated the prices of inputs and outputs and administratively allocated inputs and outputs, via a state bureaucracy, with compulsory prices set at arbitrarily low levels.

As a result of the compulsory cooperative form and the repression of internal and external trade in the economy, there was no incentive for farmers to use natural resources efficiently. The output of agriculture as well as food grain production fell markedly in the period 1977-80 (see Figures 2.1 and 2.2) causing Vietnam to import a large amount of foodstuff, mainly from the former Soviet Union.

(b) De-collectivisation in rural areas and tightly controlled markets (1981-87)

In 1979-80, the Vietnamese economy had experienced extreme crises (e.g., very poor harvests, war with Cambodia, the end of aid from the Soviet Union), as a result of which a program of economic reform was implemented. The State attempted to overcome the economic crisis in particular by the de-collectivisation of agricultural production. On January 13th, 1981, the Communist Party Secretariat (CPS) issued Order No. 100, termed the 'Reform contracted work and expanded the use of output contracts with groups of workers and individual workers in the agriculture cooperative'. The output-contract system was thus introduced whereby the land was allocated to peasants so that they could themselves organise the weeding and harvesting, with the remaining operations still to be carried out by the cooperative. A quota for produce or output delivery was fixed or based of the average yield of a plot of land in the previous three years. In this period, de-collectivisation partially removed barriers imposed by centralised management and the planning bureaucracy and provided more freedom of choice over decisions regarding production and investment. Therefore the role of the farmer became that of a partial decision-maker. In general, the relationship among the state, the farm household and the market in each local district is as indicated in Figure 2.4.

Figure 2.4: **The relationship among the State, cooperative, farm household and the free market**



The State still kept control over all commercial activities at the state price, but the farmer could now control the output and distribution of his products so that the emergence of free (or black) markets was unavoidable. In fact, in this period, two parallel goods markets were existed: the state market at the state or compulsory price (at that time the state price was higher than in the previous communal period but still much lower than the market price), and the free market with free market prices. Thus, the State only partially controlled the goods market, but still fully controlled input supply (Nguyen T Khiem, 1995). In other words, although this period is characterised by a first move towards economic liberalisation, generally, a system of full domestic markets was not yet established. The farmer became a partial decision maker but the incentives for him to work hard and exploit natural resources efficiently was very limited.

Nevertheless, this system yielded positive results in output and incomes for six years but then performance deteriorated, for various micro and macroeconomic reasons. First, at the microeconomic level, while in principle the production quota was to be fixed for a period of five years, in practice it was often raised before the contract was due, minimising the possibility of surpassing the quota. The financial burden placed on the cooperative economy was very heavy on household incomes. In Cheung's (1968) terms, the "output contract" could be compared to a fixed-rent contract in which the farm household bore most if not all of the risk, which is substantial in agriculture. As a result, farm households even returned land to the cooperatives as they were unable to deliver on their quotas. At the macroeconomic level, along with tightly controlled markets and other pricing policies, an extremely over-valued exchange rate policy caused serious problems for agriculture. Overall, the lack of coordination and the lack of the comprehensiveness of the reform program was the main cause of declining food production in 1987 and 1988 (see Figure 2.2).

(c) The gradual freeing up of markets and trade liberalisation (1988-89 until the present)

As a result (especially) of severe food shortages in 1987-88, the government recognised the problem with the old output-contracts system, and a clear renovation to the program was introduced by Resolution No.10 of the Politburo (April, 1988). Under these new regulations, farm households were now linked to cooperatives by a contract allocating (conditionally private) land use and allowing for the bartering of outputs for inputs and service supplies. In short, the cooperative was changing from being a device for extracting surplus by the state to becoming a service cooperative (much like in Western farm communities). However, it still had control over land and water resources so that households had no access to land if they withdrew from the cooperative.

The new "output contracts for farm households" were set out with the following stipulations:

- *The right of property.* Land allocation was based mainly on the number of members of each household as well as their farming capacity. The farm household had the right of use over the land for 10 to 15 years. Draft animals, farm tools and some other collective assets were sold to farmers and became their private property.
- *The management of production.* The cooperative concentrated on carrying out those major support activities which can best be done on a larger scale, such as irrigation. As a result, the number of cooperative cadres who did not directly undertake farming was reduced by as much as one half. The farm household had the full right to manage production. However, the kind of product to be produced was still determined by the cooperative just as in the traditional state planning top-down approach
- *Income distribution.* After the crop was harvested, farm households paid tax and a compulsory charge on the output per area of cultivated land. Otherwise, the farm household had the right to retain the income from their production. Farmers no longer had to sell produce to the state at below market prices. Instead, they were to

pay agricultural taxes on the basis of the yield from the land they received (on lease) from the cooperative. Indeed, the substitution of state procurement by a fixed tax removed one form of uncertainty, and in economic dealings between farmers and the State (via cooperatives or state trading companies) only one price was quoted as the 'negotiated price'. Unless there was a contract, farmers were free to sell their product on the free market. But until 1989 the local authorities forbade the peasants from selling their products out of the local district.

- *The gradual freeing up of the state planned system.* At the beginning of de-collectivisation (1981-82) the state still controlled the price system for the majority of goods. Later, under pressure from farmers,[7] the price system was freed up. In 1983, in order to absorb the left-over rice, the Central Price Committee (CPC) determined the "negotiated price" between the farmer and the state as being largely dependent on the market price and subject to mutual agreement. Under the hyper-inflation of 1988-89, the state had to resort to the barter exchange of fertiliser for rice, e.g., 1 kg of urea = 2 kg rice (SDP, 1995a). Generally, the State was still a monopsonist in the purchase of rice and farmers could not sell rice outside the local district, again at least until 1989.[8]

Finally, in June 1990, the State cancelled the dual price system (one state price and one market price) for most goods and for the exchange rate. There was only one

[7]Farmers especially in the south rejected the idea of selling their left-over rice to the state at below-market prices and contracted production. The 'negotiated price' of rice in 1989 was so low, even lower than cost of producing (CPC, 1995a), so that many farmers in the south continued to reduce production rather than sell rice to the State.

[8]In 1988, according to the Land Law (Congress Of Vietnam, 1988), or the new land for "output contract" system, production could also not be sold, leased or passed on through inheritance. Assuming that the farm household is a natural profit maximiser (Cheung, 1968), then the additional freeing up of some property rights was still required to generate more market-oriented incentives for the household.

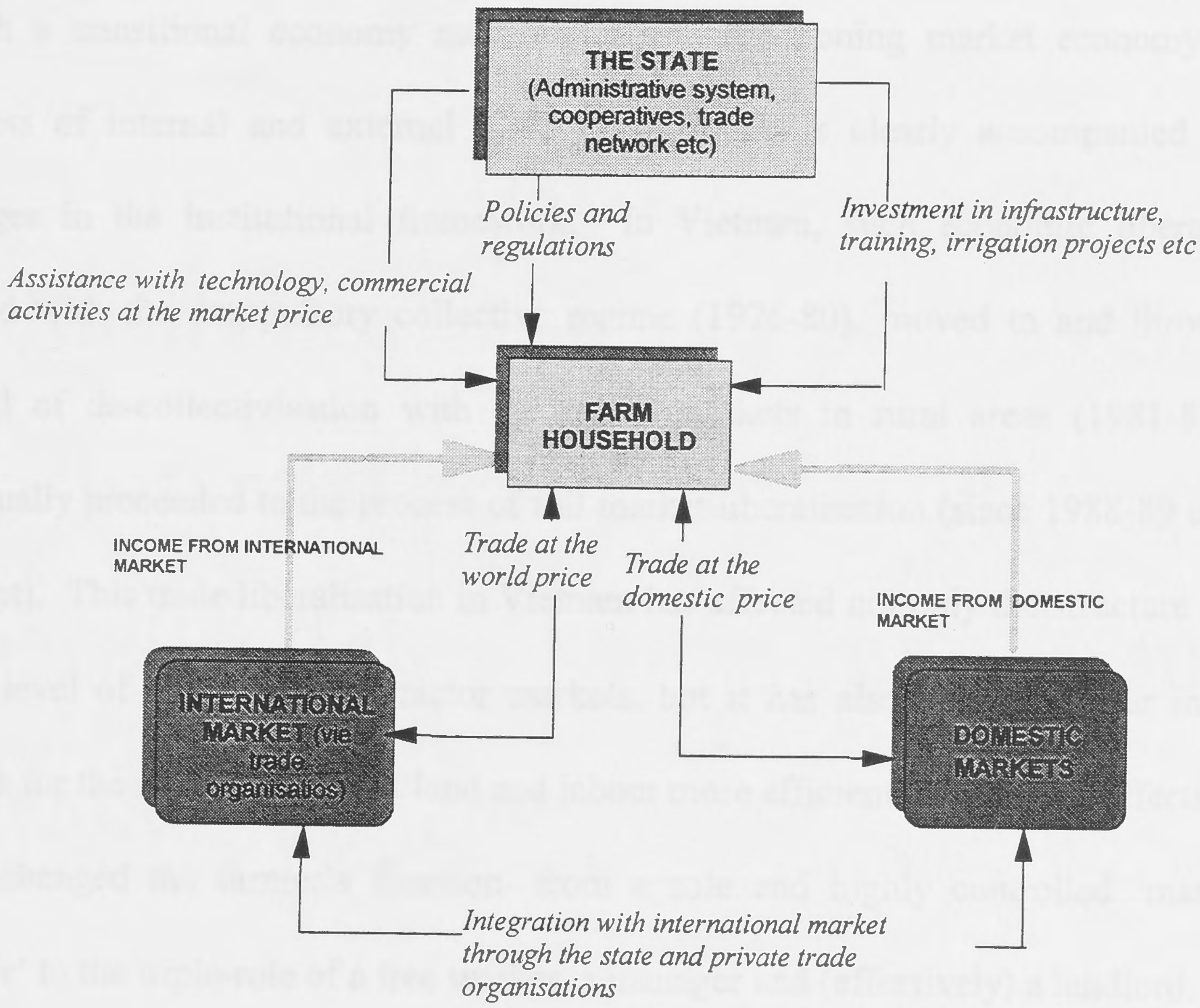
market price and no restrictions on trade in rice or any other agricultural goods. Instead of being allocated administratively, inputs and outputs were now made available for purchase and sale in decentralised markets. At the same time, economic reforms spread to every sector of the economy, such as the banking system, finance, the price system, the foreign exchange rate, trade, and so on. In fact, the process of decentralisation of the state monopoly on foreign trade started taking place in 1989, (Riedel, 1995) and most quotas were eliminated and replaced by import duties, with rates initially ranging from 5 to 50 per cent (United Nations Development Program, UNDP/ World Bank, 1994, p.48). Exchange rate reform had also been strengthened by changing from a multiple to a unified exchange rate, with liberalisation of controls on foreign exchange (Annual Reports by State Bank of Vietnam).

In July, the 1993 Land Law (Congress of Vietnam, 1993) reinforced land use rights (over the 1988 Land Law) by extending tenure over agricultural land to 20 years and introducing provisions for the selling, leasing, exchanging, mortgage, and inheritance of land. Ownership rights however, in principle, still belonged to the State (World Bank, 1995).

In the most general terms, the process of economic liberalisation, especially internal and external trade liberalisation, had developed gradually and reached a substantial degree of completeness in or about 1989-90. Since then, farmers have many options over the production and sale of output. Farmers can choose the kind of product to produce, and the form and arrangement of their farm operations. They can also deal directly in the markets for inputs and outputs. (The relationship among the State, the farm household, domestic and international markets in this period is indicated as in

Figure 2.5.)

Figure 2.5: **The relationship among the State, cooperative, farm household, domestic and international markets**



Trade has developed strongly and quickly throughout the economy. Decentralisation and the elimination of the state monopoly in foreign trade has provided opportunities for farmers to sell their products and buy necessities for production. The right to trade internationally has also been decentralised to provinces, districts and large companies. The State, however, still controls quotas or taxes and all licences to export rice, although illegal rice exports are undoubtedly still a common phenomenon which cannot be well controlled given the long borders between Vietnam, China and Cambodia.

2.3 Concluding remarks

The process of economic reform in rural areas of Vietnam nicely illustrates the steps in which a transitional economy moves to a full functioning market economy. That process of internal and external trade liberalisation is clearly accompanied by key changes in the institutional framework. In Vietnam, such economic liberalisation started with the compulsory collective regime (1976-80), moved to and through the period of de-collectivisation with controlled markets in rural areas (1981-87), and eventually proceeded to the process of full market liberalisation (since 1988-89 until the present). This trade liberalisation in Vietnam has affected not only the structure and the price level of the goods and factor markets, but it has also provided clear incentive effects for the farmer to exploit land and labour more efficiently; incentive effects which have changed the farmer's function- from a sole and highly controlled 'mandatory worker' to the triple-role of a free worker, a manager and (effectively) a landlord.

Part Two

A theoretical analysis of the effects of internal and external trade liberalisation on agricultural output and growth

Chapter 3

A STATIC MODEL OF THE EFFECTS OF INTERNAL AND EXTERNAL TRADE LIBERALISATION ON AGRICULTURAL OUTPUT

The discussion of the nature of internal and external trade liberalisation in Chapters 1 and 2 above provides the background and motivation for a more rigorous analysis of how the process of trade liberalisation can affect agricultural growth and output in a transitional economy. This chapter presents a static model of the effects of liberalisation on agricultural output. The term 'static' here means that we consider all the relevant effects at a given point of time and treat variables such as the capital stock as exogenous. Central to the analysis is the concept of an 'institutional' production function, assuming optimal choices of inputs by economic agents, which expresses output as a function of institutional factors such as property rights, markets and work incentives.

Section 3.1 defines a 'technical' production which includes measures of effective labour and land, measures that incorporate the effort associated with working harder and using land more efficiently. Section 3.2 constructs a comparable profit function for the representative farmer. Included here is the concept of net income that partially captures incentive effects through changes in average output and factor prices at different stages of market liberalisation. Section 3.3 ties the concepts of Sections 3.1 and 3.2 together and derives the institutional production function. Section 3.4 provides some concluding remarks and Appendices 3A and 3B collect technical details.

3.1 The 'technical' production function for agriculture

Assume that a farmer can choose the effort with which he or she works. If N represents the total number of workers and ε_1 is the effort of a typical farmer, the contribution of labour to output measured in efficiency units may be written as $\varepsilon_1 N$ (see McMillan, Whalley and Zhu, 1989). In fact, the role of ε_1 should be interpreted broadly to include everything that determines the quality of labour, such as the farmer's willingness to literally exert more effort as well as the enhanced effects of removing externally imposed restrictions on the kinds of tasks a farmer may undertake.

In the communal system the farmer did not have any choice in the types of crops to plant or the way in which the work was performed or the farm managed. After the process of trade liberalisation, farmers were allocated conditional property rights to land, and they were also granted the freedom to choose which products to grow. The individual farmer had the right to manage production and determine necessary input requirements. In other words, the farmer had an incentive to choose the optimal or most efficient manner to exploit a given area of land.

Next, and likewise, let L represent total sown area and ε_2 be the effort involved in exploiting and managing the land, such as increasing (optimally) the number of different crops sown in a fixed area, at the appropriate time, or simply, the level of planning involved in increasing the yield on a given amount of land. The value of ε_2 is thus considered as the optimal choice of effort in the exploitation of land, so that the total contribution of land to output measured in efficiency units is $\varepsilon_2 L$. Based on the efficient exploitation of land, a farmer will use inputs (that is, variable costs of production) such as fertiliser, pesticides, and seeds in order to maximise profit. The fixed costs associated with capital, such as machines, tools and irrigation are also required.

The empirical literature on aggregate agricultural production functions for twenty-two less developed countries (Hayami and Ruttan, 1985), and China (Tang, 1980), indicates that a typical aggregate production function is adequately captured by a Cobb-Douglas form, with constant returns to scale. Assuming such, and using the concepts of effective labour and land above, the production function is given by

$$Q = \alpha_0 (\varepsilon_1 N)^{\alpha_1} (\varepsilon_2 L)^{\alpha_2} (K_1)^{\alpha_3} (K_2)^{\alpha_4} \tag{3.1}$$

where Q, K_1, and K_2 represent total output, current inputs (other than land and labour) and physical capital respectively. Indexing by i, when necessary, the values α_i define share parameters on factor inputs, restricted in such a way that $0 < \alpha_1, \alpha_2, \alpha_3, \alpha_4 < 1$ and $\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4 = 1$.

In per-capita terms, the quantity produced by a representative farmer q is thus

$$q = \frac{Q}{N} = \alpha_0 \varepsilon_1^{\alpha_1} (\frac{N}{N})^{\alpha_1} \varepsilon_2^{\alpha_2} (\frac{L}{N})^{\alpha_2} (\frac{K_1}{N})^{\alpha_3} (\frac{K_2}{N})^{\alpha_4} \tag{3.2}$$

or

$$q = \alpha_0 \varepsilon_1^{\alpha_1} \varepsilon_2^{\alpha_2} (l)^{\alpha_2} (k_1)^{\alpha_3} (k_2)^{\alpha_4} \tag{3.3}$$

where q, l, k_1, k_2 represent output, land, current inputs and physical capital per farmer respectively, or more simply

$$q = B\varepsilon_1^{\alpha_1}\varepsilon_2^{\alpha_2} \tag{3.4}$$

for $B = \alpha_0(l)^{\alpha_2}(k_1)^{\alpha_3}(k_2)^{\alpha_4}$, so that the form of production function for a representative farmer clearly includes the farmer's choices of effort to work harder or to use the land more efficiently.

3.2 The profit function for a representative farmer

The net income or profit (Π) for a representative farmer is equal to total income (y) minus total cost (C). We will consider how liberalisation in the goods and factor markets affects total income and total cost, so that the change in profits under the effects of trade liberalisation can be clearly illustrated.

(a) Total income for a representative farmer

We suppose that each farmer receives an income that depends on his or her contribution to production and is given by

$$y = \beta p(q - d) \tag{3.5}$$

where p is the price of the agricultural good at which output is sold,[1] q is the quantity of per capita output produced by the farmer and d is a constant term that can be considered as the fixed rent or lump-sum tax the farmer has to deliver to the state for the right to use the property, regardless of yield. The value β is the fraction of the additional

[1] It is noted that the prices for output and inputs in the different years (as used in the comparative analysis of Chapter 4 and the empirical study in Part Three) are required to be adjusted into constant prices given a base year or a constructed real price in terms of a specific numeraire. See Section DA.3, Data Appendix, for a further discussion of how the prices in the different years can be calculated to obtain real prices for the case of Vietnam.

revenue generated that the farmer is allowed to keep, so that β can be considered as a share-cropping contract between the landlord (the state) and the farmer. Here, the value βp is defined as an average goods price and it includes three components given by

$$\beta p = (\beta_0 p_s + \beta_1 p_M + \beta_2 p_W) \tag{3.6}$$

where $\sum_{i=0}^{2} \beta_i = 1$ and p_s, p_M, p_W are the state price, the market clearing price and the export price respectively; and β_0, β_1 and β_2 are the fractions or shares of agricultural output allocated or delivered to the state, the domestic market, or sold internationally. As such, the relative values of the coefficients β_0, β_1 and β_2 mimic or reflect the industrial structure of the goods market, or the extent to which private market competition (or non-state intervention) predominates, or not.

Indeed, equation (3.5) does not indicate all the complexities of the various payment systems, but it can capture the main features of how the values of c, p and β vary during the reform process. Under the communal system, after submitting the compulsory tax to the state, the entire remaining output had to be sold to the state at the given state price. After the de-collectivisation of property rights and the granting of free management in production (although there was still a tight domestic market, with state-regulated restrictions on the quantity of agricultural goods sold), the farmer could keep a small amount of output and sell it in limited and very local domestic markets. After the opening-up of the domestic market, the farmer could keep the whole of net output (after tax) and sell it freely in the market place, and finally, with the development of the international market for agricultural goods, the farmer could sell a fraction of net output (given as a state-restricted amount or quota) to the world market via state-owned trade organisations at the world price. Various values for β_0, β_1 and β_2 thus imply different prevailing regimes and induce different incentives (or not) for the farmer to maximise profits by working harder and using natural resources more efficiently.

(b) The cost function for a representative farmer

Assume that the farmer chooses inputs in order to minimise cost, and that the cost function for a representative farmer takes a Cobb-Douglas form with constant returns to scale. Total cost for the assumed agricultural production function is given by[2]

$$TC = C_0 \prod_{i=1}^{4} w_i^{\alpha_i} Q \tag{3.7}$$

where TC, C_0 and w_i (i=1,4) represent total cost, a constant coefficient, and the factor prices for labour, land, current inputs, and capital respectively. Let C_0 be given as

$$C_0 = \alpha_0^{-1} \alpha_1^{1-\alpha_1} \alpha_2^{-\alpha_2} \alpha_3^{-\alpha_3} \alpha_4^{-\alpha_4} \tag{3.8}$$

so that the value of C_0 is constant and depends on the share parameters of inputs in the 'technical' production function in a given or specific economy.[3]

Defining

$$W(w_i) = \prod_{i=1}^{4} w_i^{\alpha_i} \tag{3.9}$$

as the average (real) factor price, the total cost function can be rewritten as

$$TC = C_0 W(w_i) Q \tag{3.10}$$

so that from equation (3.10) the cost of production (C) for a representative farmer depends on the quantity produced and the average factor price and can be given as

[2] See Appendix 3A for the relevant derivation.

[3] If α_0= 1 and the values of α_1, α_2, α_3 and α_4 are estimated at 0.53, 0.1, 0.21 and 0.16 respectively for twenty LDC's (Hayami, and Ruttan, 1985) then C_0 is 1.67. Likewise, the values 0.5, 0.25, 0.1 and 0.15 for China (Tang, 1980) also imply that the value of C_0 is 1.67.

$$C = C_0 W(w_i) q . \tag{3.11}$$

It is understood that the average factor price depends not only on changes in factor prices *per se* but also on changes in the composition of inputs, and those in particular that now receive explicit income payments. During the process of liberalisation, factor markets changed considerably in terms of both their structure and their speed of development. At 'early' stages, some types of inputs were 'free' (such as the labour of the farmer), or unpaid, receiving only implicit or in-kind payments. With market liberalisation such payments became explicit.

(c) The net income or profit function for a representative farmer

The various values for average output price (βp) and the average factor price ($W(w_i)$) represent the different incentives given to the farmer in order to maximise profits by working harder and using natural resources more efficiently. If profit is defined as the difference between total income and total cost, then the profit function for the farmer is given from equations (3.5) and (3.11), or

$$\Pi = \beta p(q-d) - C_0 W(w_i) q \tag{3.12}$$

where the values of βp, C_0 and $W(w_i)$ are as given in equations (3.6), (3.8) and (3.9).

Next, define the average weighted-cost share parameter m as the ratio between the average factor price and the average output price, determined as $m = \dfrac{W(w_i)}{\beta p}$ or

$$W(w_i) = m\beta p. \tag{3.13}$$

This will make it possible to capture in the value m the effects of the relative changes between the average output price and average factor prices, given changes in both goods and factor markets at different stages of liberalisation. Substituting the value of m from (3.13) into (3.12), implies that the profit function for a farmer is now given by

$$\Pi = \beta p[\ q(1 - C_0 m) - d\ ]. \tag{3.14}$$

The farmer can thus produce agricultural output only when the cost per unit is (weakly) smaller than the price per unit of output, or when C_0m is less than or equal to one. (In the long-run with constant returns to scale this value will be one, or economic profits are zero.)

3.3 The derivation of the 'institutional' production function

To complete the model, assume now that the farmer receives utility from income but dislikes the effort of hard work and the toil and effort of planning for the more efficient exploitation of the land. In general the utility function can be written as a function of profit and the optimal choice of effort, or $U(\Pi, \varepsilon_1, \varepsilon_2)$. The partial derivative of utility with respect to profit is assumed to be positive and its partial derivative with respect to each type of effort is assumed to be negative.

By maximising the farmer's utility (with effort as arguments in the utility function), subject to a profit function, we can obtain solutions for the optimal choice of effort, or ε_1^* and ε_2^*. Substituting the values of ε_1^* and ε_2^* into equation (3.3) and multiplying by the amount of labour, gives (as we will see) the new institutional production function.

To do this, we assume the utility function takes the form

$$U(\Pi, \varepsilon_1, \varepsilon_2) = \Pi - \frac{\varepsilon_1^{\ z}}{z\delta} - \frac{\varepsilon_2^{\ z}}{z\delta} \tag{3.15}$$

where $\delta > 0$ and $z > 1$ are constants, so that (as noted above) the marginal disutility of effort, or $\varepsilon_1^{z-1}/\delta$ and $\varepsilon_2^{z-1}/\delta$, increases with effort. The effort-disutility coefficient, or z, is such that

$$z-1=\varepsilon_1 \frac{\partial^2 U/\partial \varepsilon_1^{\,2}}{\partial U/\partial \varepsilon_1}=\varepsilon_2 \frac{\partial^2 U/\partial \varepsilon_2^{\,2}}{\partial U/\partial \varepsilon_2} \tag{3.16}$$

so that z measures the curvature of the utility function and is analogous to the 'coefficient of relative risk aversion'. For simplicity, the utility function, or (3.15), also implies that the disutility of effort is independent of the level of income. Substituting (3.5) into (3.15) gives

$$U(\Pi,\varepsilon_1,\varepsilon_2)=\beta p[\ B\varepsilon_1^{\alpha_1}\varepsilon_2^{\alpha_2}(1-C_0 m)-d\ ]-\frac{\varepsilon_1^{\ z}}{z\delta}-\frac{\varepsilon_2^{\ z}}{z\delta}. \tag{3.17}$$

Consider the farmer's optimal choice of effort. Maximising (3.17) with respect to ε_1, and ε_2 implies that the optimal value of ε_1 and ε_2 must satisfy[4]

$$\varepsilon_1^* = (B_1 \alpha_1^{\frac{z-\alpha_2}{z}} \alpha_2^{\frac{\alpha_2}{z}})^{\frac{1}{z-\alpha_1-\alpha_2}} \tag{3.18}$$

$$\varepsilon_2^* = (B_1 \alpha_2^{\frac{z-\alpha_1}{z}} \alpha_1^{\frac{\alpha_1}{z}})^{\frac{1}{z-\alpha_1-\alpha_2}} \tag{3.19}$$

for $B_1=\delta\beta p(1-C_0 m)B=\delta\beta p(1-C_0 m)\alpha_0(l)^{\alpha_2}(k_1)^{\alpha_3}(k_2)^{\alpha_4}$.

Substituting (3.18) and (3.19) into the per worker production function (equation 3.3), and multiplying both sides of that equation by N, converts back to aggregate variables (see Appendix 3B). This gives the institutional production function, or

$$Q=A(N)^{\gamma_1}(L)^{\gamma_2}(K_1)^{\gamma_3}(K_2)^{\gamma_4} \tag{3.20}$$

where the total factor productivity coefficient A is given by

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[4]See Appendix 3B for the relevant derivation.

$$A = (\alpha_0)^{\frac{z}{z-\alpha_1-\alpha_2}} \left[\delta\beta p(1 - C_0 m) \right]^{\frac{\alpha_1+\alpha_2}{z-\alpha_1-\alpha_2}} (\alpha_1)^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}} (\alpha_2)^{\frac{\alpha_2}{z-\alpha_1-\alpha_2}} \tag{3.21}$$

and the share parameter for labour, land, current input expenditures (e.g., fertiliser) and capital in the institutional production function are respectively

$$\gamma_1 = \frac{z\alpha_1 - \alpha_1 - \alpha_2}{z - \alpha_1 - \alpha_2} \tag{3.22}$$

$$\gamma_2 = \frac{z\alpha_2}{z - \alpha_1 - \alpha_2} \tag{3.23}$$

$$\gamma_3 = \frac{z\alpha_3}{z - \alpha_1 - \alpha_2} \tag{3.24}$$

and

$$\gamma_4 = \frac{z\alpha_4}{z - \alpha_1 - \alpha_2}. \tag{3.25}$$

Most importantly, the institutional production function, or equation (3.20), is distinguished from the 'technical' production function given by equation (3.1) because, while (3.1) reflects the technical relationship betweens inputs and outputs, equation (3.20) captures directly the farmer's response to the institutional arrangements (and the resulting enhanced incentives) within which they work. Note that the institutional production function is characterised by constant returns to scale, since

$$\gamma_1 + \gamma_2 + \gamma_3 + \gamma_4 = \frac{z(\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4) - \alpha_1 - \alpha_2}{z - \alpha_1 - \alpha_2} = 1 \tag{3.26}$$

and that the institutional production function is expressed in terms of the observable labour and land input (*N* and *L*), whereas the technical production function is expressed in terms of the unobservable efficiency measures of labour ($\varepsilon_1 N$) and land ($\varepsilon_2 L$). It is equation (3.20) rather than (3.1) that would be estimated by a conventional production function estimation, and the estimated factor shares would be γ_i rather than those of the technical production relationship, or α_i. The parameter A would be estimated as the coefficient for total factor productivity rather than the value α_0.

Note too, that the parameters α_0 and α_1 are technologically determined and that δ and z are taste parameters, all of which are invariant to institutional form. The key variables are price (p), the goods market share (β), and the relative price change between average output price and average input price (m).

3.4 Concluding remarks

This chapter provides a model that shows the effects on agricultural output due to the enhanced incentives that result from liberalisation in transitional economies. Trade liberalisation, or the gradual "freeing-up" of domestic and international markets, accompanied by changes in the institutional framework (especially with regard to property rights), can affect the amount of effort involved in the efficient exploitation of labour and land.

On this basis, a key concept in this chapter is the notion of an 'institutional' production function, which reflects not only the usual technical relationship between inputs and outputs, but also incorporates the farmers' response to the institutional and market arrangements within which they work. In the institutional production function, total factor productivity and the optimal choice of effort depend both on the price level and structure of the goods and factor markets. These variables clearly differ from one stage of liberalisation to the next. The effect of each stage of liberalisation on total productivity and the farmer's optimal choice of effort is the central topic of the next chapter.

Appendix 3A: THE FORMATION OF THE COST FUNCTION

Consider the cost minimisation problem for agricultural production, as

$$TC(w,Q) = \min_{N,L,K_1K_2} (w_1 N + w_2 L + w_3 K_1 + w_4 K_2) \tag{3A.1}$$

such that

$$Q = \alpha_0 (N)^{\alpha_1} (L)^{\alpha_2} (K_1)^{\alpha_3} (K_2)^{\alpha_4} \tag{3A.2}$$

where w_1, w_2, w_3 and w_4 are the wage of labour, the opportunity cost of land, the price of current inputs and capital respectively. The appropriate Lagrangian function is

$$\mathcal{L} = w_1 N + w_2 L + w_3 K_1 + w_4 K_2 - \lambda\left[\ Q - \alpha_0 (N)^{\alpha_1} (L)^{\alpha_2} (K_1)^{\alpha_3} (K_2)^{\alpha_4}\ \right] \tag{3A.3}$$

and solving in terms of first order conditions gives

$$L = \left(\frac{w_1 \alpha_2}{w_2 \alpha_1}\right)(N) \tag{3A.4}$$

$$K_1 = \left(\frac{w_1 \alpha_3}{w_3 \alpha_1}\right)(N) \tag{3A.5}$$

and

$$K_2 = \left(\frac{w_1 \alpha_4}{w_4 \alpha_1}\right)(N). \tag{3A.6}$$

Substituting equations (3A.4)-(3A.6) into (3A.2) and solving gives

$$N = C_0 w_1{}^{\alpha_1 - 1} w_2{}^{\alpha_2} w_3{}^{\alpha_3} w_4{}^{\alpha_4} Q \tag{3A.7}$$

$$L = C_0 \left(\frac{\alpha_2}{\alpha_1}\right) w_1{}^{\alpha_1} w_2{}^{\alpha_2 - 1} w_3{}^{\alpha_3} w_4{}^{\alpha_4} Q \tag{3A.8}$$

$$K_1 = C_0 \left(\frac{\alpha_3}{\alpha_1}\right) w_1{}^{\alpha_1} w_2{}^{\alpha_2} w_3{}^{\alpha_3 - 1} w_4{}^{\alpha_4} Q \tag{3A.9}$$

and

$$K_2 = C_0\left(\frac{\alpha_4}{\alpha_1}\right)w_1^{\alpha_1}w_2^{\alpha_2}w_3^{\alpha_3}w_4^{\alpha_4-1}Q \tag{3A.10}$$

where

$$C_0 = \alpha_0^{-1}\alpha_1^{1-\alpha_1}\alpha_2^{-\alpha_2}\alpha_3^{-\alpha_3}\alpha_4^{-\alpha_4}. \tag{3A.11}$$

Finally, substituting (3A.7) through (3A.10) into the cost function or (3A.1) implies that

$$TC = C_0 w_1^{\alpha_1}w_2^{\alpha_2}w_3^{\alpha_3}w_4^{\alpha_4}Q \quad \text{or } TC = C_0W(w_i)Q \tag{3A.12}$$

where

$$W(w_i) = w_1^{\alpha_1}w_2^{\alpha_2}w_3^{\alpha_3}w_4^{\alpha_4}. \tag{3A.13}$$

The cost function for a representative farmer is thus given by

$$C = C_0W(w_i)q \tag{3A.14}$$

as in the equation (3.11) in the chapter above.

Appendix 3B: THE FORMATION OF THE 'INSTITUTIONAL' PRODUCTION FUNCTION

The idea is to maximise the utility function of the representative farmer given by

$$U(\Pi, \varepsilon_1, \varepsilon_2) = \Pi - \frac{\varepsilon_1^{\,z}}{z\delta} - \frac{\varepsilon_2^{\,z}}{z\delta}. \tag{3B.1}$$

for

$$\Pi = \left[\beta p(1 - C_0m)q - d\right]. \tag{3B.2}$$

The quantity produced by a representative farmer is

$$q = \alpha_0\varepsilon_1^{\alpha_1}\varepsilon_2^{\alpha_2}(l)^{\alpha_2}(k_1)^{\alpha_3}(k_2)^{\alpha_4} \tag{3B.3}$$

where q, l, k_1, k_2 represent output, land, current inputs and capital per farmer respectively, or

$$q = B\varepsilon_1^{\alpha_1}\varepsilon_2^{\alpha_2} \tag{3B.4}$$

for

$$B = \alpha_0 (l)^{\alpha_2} (k_1)^{\alpha_3} (k_2)^{\alpha_4} . \tag{3B.5}$$

The first order condition with respect to ε_1 is

$$\frac{\partial U}{\partial \varepsilon_1} = \beta p(1 - C_0 m) B \alpha_1 \varepsilon_1^{\alpha_1 - 1} \varepsilon_2^{\alpha_2} - \frac{\varepsilon_1^{z-1}}{\delta} = 0 \tag{3B.6}$$

and solving gives

$$\varepsilon_1^{z-\alpha_1} = B_1 \alpha_1 \varepsilon_2^{\alpha_2} \tag{3B.7}$$

and

$$\varepsilon_1^* = (\alpha_1 B_1 \varepsilon_2^{\alpha_2})^{1/(z-\alpha_1)} \tag{3B.8}$$

for $B_1 = \delta\beta p(1 - C_0 m) B$. By symmetry, from $\dfrac{\partial U}{\partial \varepsilon_2} = 0$, we get the result for the optimal value of ε_2 as

$$\varepsilon_2^* = (\alpha_2 B_1 \varepsilon_1^{\alpha_1})^{1/(z-\alpha_2)} . \tag{3B.9}$$

Next, solve equations (3B.8) and (3B.9) simultaneously, as follows. The value of

$$B_1 = (\varepsilon_2^{z-\alpha_2} \varepsilon_1^{-\alpha_1}) / \alpha_2 = (\varepsilon_1^{z-\alpha_1} \varepsilon_2^{-\alpha_2}) / \alpha_1 \tag{3B.10}$$

which implies that

$$(\frac{\alpha_2}{\alpha_1}) = (\frac{\varepsilon_2^z}{\varepsilon_1^z})$$

and

$$\varepsilon_2^* = (\frac{\alpha_2}{\alpha_1})^{\frac{1}{z}} \varepsilon_1^* \tag{3B.11}$$

Substituting the values (3B.11) into equation (3B.9) gives

$$\varepsilon_1 = \left[\alpha_1 B_1 (\frac{\alpha_2}{\alpha_1})^{\frac{\alpha_2}{z}} \varepsilon_1^{\alpha_2} \right]^{\frac{1}{z-\alpha_1}} \tag{3B.12}$$

or $\varepsilon_1^{z-\alpha_1-\alpha_2} = B_1 \alpha_1^{\frac{z-\alpha_2}{z}} \alpha_2^{\frac{\alpha_2}{z}}$, so that

$$\varepsilon_1^* = (B_1 \alpha_1^{\frac{z-\alpha_2}{z}} \alpha_2^{\frac{\alpha_2}{z}})^{\frac{1}{z-\alpha_1-\alpha_2}} \tag{3B.13}$$

with $B_1 = \delta\beta p(1 - C_0 m)\alpha_0 (l)^{\alpha_2} (k_1)^{\alpha_3} (k_2)^{\alpha_4}$. Substituting (3B.13) into (3B.11) gives

$$\varepsilon_2^* = (B_1 \alpha_2^{\frac{z-\alpha_1}{z}} \alpha_1^{\frac{\alpha_1}{z}})^{\frac{1}{z-\alpha_1-\alpha_2}} \tag{3B.14}$$

and substituting (3B.13) and (3B.14) into the per worker production function, or equation (3B.3), gives

$$q = B(B_1 \alpha_1^{\frac{z-\alpha_2}{z}} \alpha_2^{\frac{\alpha_2}{z}})^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}} (B_1 \alpha_1^{\frac{\alpha_1}{z}} \alpha_2^{\frac{z-\alpha_1}{z}})^{\frac{\alpha_2}{z-\alpha_1-\alpha_2}} \tag{3B.15}$$

so that, with the values of B and B_1,

$$q = \left[\alpha_0 (l)^{\alpha_2} (k_1)^{\alpha_3} (k_2)^{\alpha_4}\right]^{\frac{z}{z-\alpha_1-\alpha_2}} (\delta\beta p)^{\frac{\alpha_1+\alpha_2}{z-\alpha_1-\alpha_2}} (\alpha_1)^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}} (\alpha_2)^{\frac{\alpha_2}{z-\alpha_1-\alpha_2}}. \tag{3B.16}$$

Finally, multiplying both sides of equation (3B.16) by N converts back to aggregate variables, or

$$Q = (\alpha_0)^{\frac{z}{z-\alpha_1-\alpha_2}} [\ \delta\beta p(1 - C_0 m)\ ]^{\frac{\alpha_1+\alpha_2}{z-\alpha_1-\alpha_2}} (\alpha_1)^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}} (\alpha_2)^{\frac{\alpha_2}{z-\alpha_1-\alpha_2}} N^{1-\frac{z}{z-\alpha_1-\alpha_2}(\alpha_2+\alpha_3+\alpha_4)}$$
$$(lN)^{\frac{\alpha_2 z}{z-\alpha_1-\alpha_2}} (k_1 N)^{\frac{\alpha_3 z}{z-\alpha_1-\alpha_2}} (k_2 N)^{\frac{\alpha_4 z}{z-\alpha_1-\alpha_2}}. \tag{3B.17}$$

Define the total factor productivity A as

$$A = (\alpha_0)^{\frac{z}{z-\alpha_1-\alpha_2}} [\ \delta\beta p(1 - C_0 m)\ ]^{\frac{\alpha_1+\alpha_2}{z-\alpha_1-\alpha_2}} (\alpha_1)^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}} (\alpha_2)^{\frac{\alpha_2}{z-\alpha_1-\alpha_2}} \tag{3B.18}$$

where the parameter shares of labour factor, land factor, current input expenditures and capital in the institutional production function are respectively

$$\gamma_1 = 1 - \frac{z}{z-\alpha_1-\alpha_2}(\alpha_2+\alpha_3+\alpha_4) = \frac{z\alpha_1 - \alpha_1 - \alpha_2}{z - \alpha_1 - \alpha_2} \tag{3B.19}$$

$$\gamma_2 = \frac{z\alpha_2}{z - \alpha_1 - \alpha_2} \tag{3B.20}$$

$$\gamma_3 = \frac{z\alpha_3}{z - \alpha_1 - \alpha_2} \tag{3B.21}$$

and

$$\gamma_4 = \frac{z\alpha_4}{z - \alpha_1 - \alpha_2} \tag{3B.22}$$

so that value of Q in equation (3B.17), after substitution, can finally be defined or rewritten in the form of the institutional production function, or

$$Q = A(N)^{\gamma_1}(L)^{\gamma_2}(K_1)^{\gamma_3}(K_2)^{\gamma_4} \tag{3B.23}$$

as given by equation (3.20) in the chapter above.

Chapter 4

A COMPARATIVE STATICS ANALYSIS OF THE EFFECTS OF INTERNAL AND EXTERNAL TRADE LIBERALISATION ON AGRICULTURAL GROWTH

Given the effects of trade liberalisation, Chapter 3 provided the form of the 'institutional' production function. Based upon this work, this chapter provides a simple theoretical analysis of the comparative statics effects that result from the various stages of internal and external trade liberalisation on agricultural growth. A key concern is the change in total factor productivity *(A)* and the farmer's optimal choice of effort $(\varepsilon_1, \varepsilon_2)$ given changes in the average goods price (βp) and the average weighted-cost share parameter (m), or the average factor price $(W(w_i))$, across different periods or stages of liberalisation. Section 4.1 deals specifically with the changes in the goods and factor markets, while Section 4.2 discusses the resulting effects on total factor productivity. Section 4.3 characterises the farmer's optimal choice of effort in different stages of trade liberalisation and, for completeness, Section 4.4 determines the share parameters of factor inputs in the institutional production function. Section 4.5 concludes and Appendix 4A considers the case of changes in m specific to Vietnam.

4.1 The goods and factor markets in the different stages of trade liberalisation

Based on the definitions in Chapter 3, recall that the average goods price (βp) and the average factor price $W(w_i)$ reflect the price level and the structure of the goods and factor markets, whereas the average weighted-cost share parameter *(m)* reflects the relative changes between the goods and factor markets. As such, the analyses of the goods and factor markets can be characterised through changes in these parameters across the different (institutional) stages of trade or market liberalisation.

(a) Changes in the goods market

Return to the components of the average goods price βp given in equation (3.6), renumbered here for convenience

$$\beta p = (\beta_0 p_s + \beta_1 p_M + \beta_2 p_W) \tag{4.1}$$

so that the average goods price (βp) depends on the market shares allocated among the State, the domestic and the international markets (β_0, β_1 and β_2), and the price levels (p_S, p_1, p_2) which differ from one stage of trade liberalisation to the other. Likewise, the various values of β_0, β_1 and β_2 represent the different structure of the goods markets in the different stages of trade liberalisation.

In the period of the communal system, the farmer has to sell to the State the entire agricultural output at the low, state controlled price (p_S). He (or she) cannot freely sell products in the domestic or international market, so

$$\beta_0^C = 1; \beta_1^C = 0; \beta_2^C = 0. \tag{4.2}$$

In the period of output contracts with a tightly controlled markets the farmer still has to sell the major share of output to the State at the low compulsory price, but he (or she) can also sell a small fraction of output to the domestic market (β_1^D), at the market price. In other words, the domestic market is operating but it is still tightly regulated and there exist two parallel price systems for agricultural goods (the state and domestic market prices). The values of β in this case are

$$1 > \beta_0^D > 0; 1 > \beta_1^D > 0; \beta_2^D = 0; \beta_0^D + \beta_1^D = 1 \qquad (4.3)$$

where β_1^D is very small.

In the period of a free domestic market or a full internal trade liberalisation, the State allows the domestic market to trade freely. Freedom of purchase and sale of agricultural goods is permitted and the barriers to market entry are removed. The price controls by government are also removed so that the prices for agricultural goods reflect their real or market value. Under this regime, the farmer has the full freedom to sell products in the domestic market at the market price, but he still cannot enter the international market. Thus, under this regime, the market share components are determined as

$$\beta_0^M = 0; \beta_1^M = 1; \beta_2^M = 0. \qquad (4.4)$$

In the period of the opening up of the international market or that of external trade liberalisation, the State removes the trade barriers to international markets and decentralises the government trade monopoly. Moreover, the State implements the necessary reforms in exchange rate policy so that a new, more appropriate exchange rate more closely reflects the 'real' or true market value of the domestic currency. The farmer can thus export (via competitive trade organisations) a market share (β_2^W) of goods to the international market at a world price and also have the freedom to sell his product in the domestic market. Therefore, in this period, the market shares between the State, the domestic market and international markets are as follows

$$\beta_0^W = 0; 1 > \beta_1^W > 0; 1 > \beta_2^W > 0; \beta_1^W + \beta_2^W = 1. \quad (4.5)$$

Corresponding to the market shares β_0, β_1 and β_2 are different price levels p_S, p_1, p_2 for the State, domestic and international markets respectively. Assume, as is the actual case for Vietnam (see the Data Appendix), that during the transitional periods, the product price increases over time in the different stages of liberalisation, or

$$p_S < p_D < p_M < p_W. \quad (4.6).$$

This assumption comes from an argument (and actual fact) that in the communal system the State determines the price (p_S) and that it is invariably lower than the market clearing price (p_M) that corresponds to the period of free domestic markets. It is noted that the value of the export price in terms of domestic currency depends on the exchange-rate regime in place. In this case, we assume that with reform the exchange rate reflects a true market value, so that for the food-export economy the market clearing price (p_M) is lower than the export price (p_W).

(b) Changes in the factor market

As mentioned earlier (Section 3.2, Chapter 3), the average factor price ($W(w_i)$) is a measure of the explicit expenditure on inputs that farmers have to pay. Thus, the average factor price ($W(w_i)$) depends on not only the level of each factor price but also on the degree or development of factor markets, especially (but not exclusively) for the cases in which previously non-tradeable goods or inputs become tradeable. In the period of the communal system many kinds of inputs and were either non tradeable or unpaid, in that the farmer got them 'free' (e.g., allocated land and labour, the state's investment goods, and various subsidies). The cooperative then distributed income to farmers by egalitarian means depending on a work-point system, with no explicit wage rate being determined for labour. As such, we can assume that the main explicit payment for inputs is for current inputs or chemical fertiliser so that the average factor price is given by

$$W(w_i) = (w_3^S)^{\alpha_3} \tag{4.7}$$

where w_3^S is the state or low price of fertiliser.

In the period of output contracts, with tightly controlled markets, the State loosens or opens up the input market, but mainly (in the case of Vietnam) just for materials like fertiliser and insecticide. In this period of time the farmer is able to purchase a small amount of such materials from private commercial companies at a domestic market price ($w_3^M > w_3^S$), but with no other changes in the rest of the input market. The value of average factor price is still defined as in equation (4.7) but input prices as a whole rise due to the increase in the (two parallel) state and domestic market prices for fertiliser and insecticide.

In the period of a free domestic market, the State permits the domestic market to trade agricultural inputs freely and the barriers to market entry are removed. Under this regime, farmers have the full freedom to buy inputs in the domestic market at market prices but they still cannot purchase inputs from the international market at the world price (which, again, in practice, is often cheaper than the domestic market-clearing price). The development of factor markets also cause some non tradeable goods such as labour and land to become paid commercial goods, i.e., farmers are now able to hire labour or rent land so that these expenditures now become explicit. The average of factor prices is thus

$$W(w_i) = (w_1^M)^{\alpha_1} (w_2^M)^{\alpha_3} (w_3^M)^{\alpha_4}. \tag{4.8}$$

Finally, in the period of the opening up of the international market, there is more freedom for state organisations or the private sector to enter the international market. With the exception of some trade restrictions such as quotas or taxes, farmers can buy (via the trade organisations) from the international market and have the full freedom to purchase inputs in the domestic market. If we assume that there are still restrictions in the market for land, the average factor price still follows equation (4.8), but current inputs are now purchased at the world price. However, if the land market also develops so that the State now permits the leasing, selling, mortgage and inheritance of land then all of the input factors are now included in the average factor price so that

$$W(w_i) = \prod_{i=1}^{4} (w_i^W)^{\alpha_i}. \tag{4.9}$$

While it is clear that the liberalisation increases the number of inputs that are taken into account as explicit expenditure payments, it is not always clear whether the price of inputs as a whole becomes more or less expensive. For example, in the case of Vietnam with *full* market liberalisation (see Section DA.3, Data Appendix) the price of fertiliser became cheaper while the price of land and labour became more expensive.

(c) The relative changes between the goods and the factor markets

The analysis above discussed the changes in the goods and factor markets separately but the institutional production function used in Chapter 3 is expressed in terms of the average weighted-cost share parameter *(m),* which is the ratio between the average goods and average factor prices, or $W(w_i)/\beta p$ (see equation (3.13)). Depending on the specific situation of the economy and the pattern of development between the goods and factor markets, the possibility of changes in the value of m is clearly different. In what follows we discuss all the possible changes in m (constant, decreasing and increasing).

(1) m is constant ($m_S = m_D = m_M = m_W > 0$), where m_S, m_D, m_M and m_W are the average weighted-cost share parameters in the communal era, the regime of output contracts with a tightly controlled domestic market, the free domestic market and the opening up of the international market respectively. This case corresponds to the situation where liberalisation happens simultaneously in goods and factor markets and so has the same proportional effects on goods and factor prices. The increase in the average price of agricultural goods (βp) occurs at the same time and in the same proportion as the increase in average factor prices, or ($W(w_i)$). In other words, farmers benefit from higher goods prices as much as they suffer from the higher input prices.

(2) m decreases ($m_S > m_D > m_M > m_W > 0$). In this case the process of trade liberalisation causes the average product price (βp) to increase but average factor prices ($W(w_i)$) decrease or increase by a smaller proportion than the average product price. This possibility arises from the fact that in the period of the communal system the farmer receives small subsidies from the State through cheap input supplies (mainly fertiliser and insecticide), but has to sell output at a very low price. Moreover, input supplies from the State in the communal period are usually in short supply so that the farmer usually has to compensate by purchasing inputs from the black market at above the market-clearing prices. With the freeing up of domestic and international markets the main materials for agriculture become abundant at the market clearing or world prices, and undoubtedly the prices of some inputs become much cheaper (e.g., imported fertiliser). If we also assume (what seems to be true) that the development of land and labour markets is slow and weak in transitional periods, so that the only explicit expenditures are mainly for fertiliser and pesticide, the possibility of a fall in m is quite reasonable. [1] This case can be seen by the example of rice production in Vietnam (see Appendix 4A, and Table DA.10, Data Appendix). In short, the possibility of liberalisation causing a fall in m seems quite likely in transitional economies.

(3) m increases ($0<m_S<m_D<m_M<m_W$). This is the case where the development of the factor market causes the wage rate (for hired labour), the opportunity cost of using land and the prices of current inputs and physical capital to become very expensive with the average factor price for input ($W(w_i)$) increasing proportionally more than the average output price (βp). However, as discussed in (2) above, this case may be rare in transitional economies, particularly where markets for labour and land are poorly developed.

4.2 The total factor productivity coefficient (or A) in the different stages of trade liberalisation

We now consider the factor productivity coefficient. Substituting equation (3.6) into (3.21) gives a measure of total factor productivity, or A, describing in detail the various components of market shares and prices under different regimes, so that

[1] In transitional periods, the markets for land, labour, and capital are typically less extensive and developed, so that the component of explicit payments for inputs is mainly that of current inputs. In this case, Appendix 4A shows that the possibility for increase in m may be very rare.

$$A = \left[\alpha_0^z \delta^{\alpha_1+\alpha_2} \left[(\beta_0 p_s + \beta_1 p_M + \beta_2 p_W)(1 - C_0 m) \right]^{\alpha_1+\alpha_2} \alpha_1^{\alpha_1} \alpha_2^{\alpha_2}\right]^{\frac{1}{z-\alpha_1-\alpha_2}}. \quad (4.10)$$

The value A thus represents the coefficient for total factor productivity which depends on the parameters α_0, α_1 and α_2. However, A is independent of the share parameters of current input expenditures (K_1) and capital (K_2). Changes in property rights and liberalisation will affect the values of β and p and so will clearly influence the value of A. However, the value of A also depends on how the average weighted-cost share parameter (m) changes.

From equation (4.10), the growth rate of total factor productivity is given by

$$\frac{\dot{A}}{A} = \left(\frac{\alpha_1 + \alpha_2}{z - \alpha_1 - \alpha_2}\right) \frac{\beta \dot{p}(1 - C_0 m)}{\beta p(1 - C_0 m)}.$$

For convenience we use the component $\beta p(1\text{-}C_0 m)$, which is defined as the composite price between output and inputs, for the analysis to follow later.

The approximate growth rate of total factor productivity from the specified period (1) to the next period (2) can be defined by

$$\frac{\dot{A}}{A} = \frac{A^2 - A^1}{A^1} = \left(\frac{\alpha_1 + \alpha_2}{z - \alpha_1 - \alpha_2}\right) \left[\frac{(\beta p)^2 (1 - C_0 m_2) - (\beta p)^1 (1 - m_1 c)}{(\beta p)^1 (1 - C_0 m_1)}\right] \quad (4.11)$$

where $\beta p^1 = (\beta_0 p_s + \beta_1 p_M + \beta_2 p_W)^1$ and $\beta p^2 = (\beta_0 p_s + \beta_1 p_M + \beta_2 p_W)^2$ are the average price of output in periods 1 and 2 respectively and m_1 and m_2 are the average weighted-cost share parameters in periods 1 and 2 respectively.

(a) The growth of total factor productivity in the transitional periods of liberalisation

Now we are in a position to examine how the value and growth rate of total factor productivity change in the different stages of trade liberalisation. Under the communal system, substitute the value of β in equation (4.2) into (4.10) so that the value of productivity factor A^C is given by

$$A^C = \left[\alpha_0^z \delta^{\alpha_1+\alpha_2}\left[\ p_s(1-C_0 m_C)\right)^{\alpha_1+\alpha_2} \alpha_1^{\alpha_1}\alpha_2^{\alpha_2}\right]^{\frac{1}{z-\alpha_1-\alpha_2}}. \tag{4.12}$$

Everything else equal, the value of the productivity factor in the communal system can be greater if the State sets a price (p_S) which more closely reflects the real or market value of agricultural goods. But, in fact, for a variety of reasons, the compulsory (or state) price of agricultural goods is usually set very low so that the value of A^C is very small.

Under output contracts the value of the total factor productivity coefficient (A^D) also includes a partial term for the domestic market, or

$$A^D = \left[\alpha_0^z \delta^{\alpha_1+\alpha_2}\left[\ (\beta_0 p_s + \beta_1 p_M)(1-C_0 m_D)\ \right]^{\alpha_1+\alpha_2} \alpha_1^{\alpha_1}\alpha_2^{\alpha_2}\right]^{\frac{1}{z-\alpha_1-\alpha_2}} \tag{4.13}$$

with the value of βp given by (4.3). In the period of free domestic markets, substituting the value of βp from equation (4.4) into (4.10), the value of the productivity factor coefficient A^M is given by

$$A^M = \left[\alpha_0^z \delta^{\alpha_1+\alpha_2}\left[\ p_M(1-C_0 m_M)\right)^{\alpha_1+\alpha_2} \alpha_1^{\alpha_1}\alpha_2^{\alpha_2}\right]^{\frac{1}{z-\alpha_1-\alpha_2}} \tag{4.14}$$

and for the period of the opening up of the international market (with the value of βp as determined in equation (4.5)), the value of the productivity factor coefficient is given as

$$A^W = \left[\alpha_0^z \delta^{\alpha_1+\alpha_2} \left[(\beta_1 p_M + \beta_2 p_W)(1-C_0 m_W)^{\alpha_1+\alpha_2} \alpha_1^{\alpha_1} \alpha_2^{\alpha_2} \right]^{\frac{1}{z-\alpha_1-\alpha_2}}\right. . \quad (4.15)$$

The results in equations (4.12) through (4.15) allow us to derive expression for the growth rate of total factor productivity in each transitional period.

As such, the growth rate of total factor productivity in the period of output contracts compared to that of the communal system is determined from equations (4.12) and (4.13), or

$$\left(\frac{\overset{\bullet}{A}}{A}\right)^D = \frac{A^D - A^C}{A^C} = \left(\frac{\alpha_1+\alpha_2}{z-\alpha_1-\alpha_2}\right)\left[\frac{(\beta_0 p_S + \beta_1 p_M)(1-C_0 m_D) - p_S(1-m_0 c)}{p_S(1-C_0 m_0)}\right]^{\frac{1}{Z-\alpha_1-\alpha_2}} . \quad (4.16)$$

The growth rate of total factor productivity in the free domestic market compared to that in the output contracts system, as given from equations (4.13) and (4.14), is

$$\left(\frac{\overset{\bullet}{A}}{A}\right)^M = \frac{A^D - A^M}{A^C} = \left(\frac{\alpha_1+\alpha_2}{z-\alpha_1-\alpha_2}\right)\left[\frac{p_M(1-C_0 m) - (\beta_0 p_S + \beta_1 p_M)(1-C_0 m_D)}{\beta_0 p_S + \beta_1 p_M}\right]^{\frac{1}{Z-\alpha_1-\alpha_2}} \quad (4.17)$$

and the growth rate of total factor productivity in the period of the opening up of the international market, compared with that of a free domestic market, given equations (4.14) and (4.15), becomes

$$\left(\frac{\overset{\bullet}{A}}{A}\right)^W = \frac{A^W - A^M}{A^C} = \left(\frac{\alpha_1+\alpha_2}{z-\alpha_1-\alpha_2}\right)\left[\frac{(\beta_1 p_M + \beta_2 p_W)(1-C_0 m_W) - p_M}{p_M}\right]^{\frac{1}{Z-\alpha_1-\alpha_2}} . \quad (4.18)$$

The results of equations (4.16) through to (4.18) indicate that the growth rate of total factor productivity relates positively to the average goods price (βp) and negatively to the average weighted-cost share parameter (m). During process of trade liberalisation, the component (βp) increases over time but the movement of the average weighted-cost share parameter (m) is ambiguous, hence the precise conditions for a positive growth rate of total factor productivity during process of trade liberalisation needs to be considered further.

(b) The condition for positive growth of total factor productivity during the process of trade liberalisation

Relying on equations (4.11), and (4.16) to (4.18), we now examine changes in total factor productivity under the effects of trade liberalisation according to the various possibilities of the changes in the average weighted-cost share parameter (m) set out earlier. The cases are as follows:

(1) m is constant. When m is constant the level of total factor productivity jumps to a higher level when agriculture moves from one stage of trade liberalisation to the next. More specifically, with the sign of the denominator positive (see equations (4.2), (4.3) and (4.6)). the sign of the growth rate of total factor productivity from the period of the communal to the output-contract system depends on the sign of the numerator in equation (4.16), which is positive. Similarly, the growth rate of total factor productivity from the regime of output-contracts to the regime of the free domestic markets also has the same sign as the numerator in equation (4.17), which from (4.3), (4.4) and (4.6), is also positive. Relying on equations (4.18), and (4.4) to (4.6), the growth rate of total factor productivity from the period of free domestic market to the period of opening up of the international market is positive as well.

(2) m is decreasing. From the arguments above, it can be concluded that the growth rate of total factor productivity across different phases is positive. The total factor productivity jumps to an even higher level than in the previous case because m decreases. Liberalisation has a more positive effect than in the case where m is constant.

(3) m is increasing. Here, there is no strong conclusion about whether the growth rate of total factor productivity is positive or negative because m increases at the same time that βp increases. Indeed, because the sign of the growth rate of total factor productivity has the same sign as that of the numerator in equation (4.11), the growth rate of total factor productivity is positive only if

$$\beta p^2(1 - C_0 m_2) - \beta p^1(1 - C_0 m_1) > 0 \tag{4.19}$$

or, after substituting the value of m into equation (4.19),

$$\left[\ (\beta p)^2 - (\beta p)^1\ \right] - C_0\left[(W(w_i)^2 - (W(w_i)^1\ \right] > 0 \tag{4.20}$$

where $W(w_i)^1$ and $W(w_i)^1$ are the average factor price in periods 1 and 2, respectively.

In other words, the condition turns out to be that the difference in the average price of inputs must be smaller than the difference in the average price of outputs between two periods, all divided by the constant coefficient in the cost function C_0, where C_0 is defined as in (3.8), or

$$\Delta W < \frac{\Delta \beta p}{C_0}. \tag{4.21}$$

Alternatively, if the full value of the average factor price is written as in equation (3.9) the condition for an increase in total factor productivity is given as

$$\prod_{i=1}^{4}(w_i^1)^{\alpha_i} - \prod_{i=1}^{4}(w_i^2)^{\alpha_i} < \frac{\Delta \beta p}{C_0} \tag{4.22}$$

where w_i^1 and w_i^2 indicate the factor price of input i in periods 1 and 2 respectively. Assuming that there are relatively immature markets for land and labour in these transitional periods, and given that the explicit payments or expenditures mainly refer to current inputs (e.g., fertiliser, insecticide, and seeds), condition (4.22), as argued in Appendix 4A below, is easily satisfied.

If, instead, we assume that factor markets are sufficiently mature (i.e., with high demands and perfect mobility in the labour and land markets), so that explicit payments include those to labour and land as well, it is possible that the condition given by equation (4.22) may not hold. It all depends on the specific situation, of course. For example, if the farm is located next to a large city, the wage rate or the opportunity cost for using land will undoubtedly be relatively much higher than in other areas, so that the increase in total factor productivity for cultivation will thus be smaller. Nevertheless, in transitional periods, even if apparently the rare case of an increase m happens, it is still highly probable that there will be positive growth in total factor productivity under effects of trade liberalisation. In other words, it seems very unlikely that an increase in m will totally swamp the relevant price effects (see Appendix 4A).

4.3 The individual's optimal choice of effort in the different stages of trade liberalisation

Now consider the optimal choice of effort in different stages of trade liberalisation. Rewriting equations (3.18) and (3.19), with the value of B_1, the individual's optimal choice of effort can be described in terms of three components of the output market share and the output price as

$$\varepsilon_1^* = \left[\alpha_0(\beta_0 p_s + \beta_1 p_M + \beta_2 p_W)(1 - C_0 m)(l)^{\alpha_2}(k_1^{\alpha_3})(k_2^{\alpha_4})\alpha_1^{\frac{z-\alpha_2}{z}}\alpha_2^{\frac{\alpha_2}{z}})\right]^{\frac{1}{z-\alpha_1-\alpha_2}} \quad (4.23)$$

and

$$\varepsilon_2^* = \left[\alpha_0(\beta_0 p_s + \beta_1 p_M + \beta_2 p_W)(1 - C_0 m)(l)^{\alpha_2}(k_1^{\alpha_3})(k_2^{\alpha_4})\alpha_1^{\frac{\alpha_1}{z}}\alpha_2^{\frac{z-\alpha_1}{z}})\right]^{\frac{1}{z-\alpha_1-\alpha_2}}. \quad (4.24)$$

The effects of trade liberalisation on the individual's optimal choice of work effort (ε_1) and devotion to land management (ε_2) in different stages can now be considered by analysing the effects of the changes in the value of β and p within each trade liberalisation regime, given the change in m for different cases.

- ***In the communal system:*** Substituting the value of p_S and β (given in (4.2), or $\beta_0^C = 1; \beta_1^C = 0; \beta_2^C = 0$) into (4.23) and (4.24), we obtain the value of the individual's optimal choice of effort (ε_1), and the optimal choice of effort for exploiting the land (ε_2), or

$$\varepsilon_1^C = \left[\alpha_0 p_s(1 - C_0 m_C)(l)^{\alpha_2}(k_1^{\alpha_3})(k_2^{\alpha_4})\alpha_1^{\frac{z-\alpha_2}{z}}\alpha_2^{\frac{\alpha_2}{z}})\right]^{\frac{1}{z-\alpha_1-\alpha_2}} \quad (4.25)$$

$$\varepsilon_2^C = \left[\alpha_0 p_s(1 - C_0 m_C)(l)^{\alpha_2}(k_1^{\alpha_3})(k_2^{\alpha_4})\alpha_1^{\frac{\alpha_1}{z}}\alpha_2^{\frac{z-\alpha_1}{z}})\right]^{\frac{1}{z-\alpha_1-\alpha_2}} \quad (4.26)$$

  so that a low planned (or state) price for the agricultural good in the communal system leads both to low effort as well as inefficient exploitation of land.

- ***In the period of output contracts with a tightly controlled domestic market:*** Substituting p_S and β (given in (4.3), where $1 > \beta_0^D > 0; 1 > \beta_1^D > 0;\ \beta_2^D = 0$ $\beta_0^D + \beta_1^D = 1$ with β_1^D very small), so relevant effort variables are

$$\varepsilon_1^D = \left[\alpha_0(\beta_0^D p_s + \beta_1^D p_M)(1 - C_0 m_D)(l)^{\alpha_2}(k_1^{\alpha_3})(k_2^{\alpha_4})\alpha_1^{\frac{z-\alpha_2}{z}}\alpha_2^{\frac{\alpha_2}{z}})\right]^{\frac{1}{z-\alpha_1-\alpha_2}} \quad (4.27)$$

$$\varepsilon_2^D = \left[\alpha_0(\beta_0^D p_s + \beta_1^D p_M)(1-C_0 m_D)(l)^{\alpha_2}(k_1^{\alpha_3})(k_2^{\alpha_4})\alpha_1^{\frac{\alpha_1}{z}}\alpha_2^{\frac{z-\alpha_1}{z}}\right]^{\frac{1}{z-\alpha_1-\alpha_2}}. \quad (4.28)$$

- ***In the period of full freedom in the domestic market*:** Substituting the value of p_M and β (given in (4.5) where $\beta_0^M = 0; \beta_1^M = 1; \beta_2^M = 0$) into (4.23) and (4.24) we obtain

$$\varepsilon_1^M = \left[\alpha_0 p_M(1-C_0 m_M)(l)^{\alpha_2}(k_1^{\alpha_3})(k_2^{\alpha_4})\alpha_1^{\frac{z-\alpha_2}{z}}\alpha_2^{\frac{\alpha_2}{z}}\right]^{\frac{1}{z-\alpha_1-\alpha_2}} \quad (4.29)$$

$$\varepsilon_2^M = \left[\alpha_0 p_M(1-C_0 m_M)(l)^{\alpha_2}(k_1^{\alpha_3})(k_2^{\alpha_4})\alpha_1^{\frac{\alpha_1}{z}}\alpha_2^{\frac{z-\alpha_1}{z}}\right]^{\frac{1}{z-\alpha_1-\alpha_2}}. \quad (4.30)$$

- ***In the period of opening up the international market:*** From the value of β in (4.5) where $\beta_0^W = 0; 1 > \beta_1^W > 0; 1 > \beta_2^W > 0; \beta_1^W + \beta_2^W = 1$, then the value of efforts become

$$\varepsilon_1^W = \left[\alpha_0(\beta_1^W p_M + \beta_2^W p_W)(1-C_0 m_W)(la)^{\alpha_2}(k_1^{\alpha_3})(k_2^{\alpha_4})\alpha_1^{\frac{z-\alpha_2}{z}}\alpha_2^{\frac{\alpha_2}{z}}\right]^{\frac{1}{z-\alpha_1-\alpha_2}} \quad (4.31)$$

$$\varepsilon_2^W = \left[\alpha_0(\beta_1^W p_M + \beta_2^W p_W)(1-C_0 m_W)(la)^{\alpha_2}(k_1^{\alpha_3})(k_2^{\alpha_4})\alpha_1^{\frac{\alpha_1}{z}}\alpha_2^{\frac{z-\alpha_1}{z}}\right]^{\frac{1}{z-\alpha_1-\alpha_2}}. \quad (4.32)$$

Comparing equations (4.23) and (4.24) with (4.10), it can be seen that the growth of the individual's optimal choice of effort equal each other and that they also equal the growth rate of total factor productivity. Therefore, the whole analysis of the growth in the individual's optimal choice of effort is similar to that of the growth of total factor productivity. Thus, we obtain the conclusions about the positive effects of trade liberalisation on the growth rate of the individual's optimal choice of effort, solely in terms of the change in factor productivity.

4.4 The share parameters of factor inputs in the institutional production function

Finally, note the share parameters of factor inputs in the institutional production function (γ_1; γ_2; γ_3 and γ_4) are different from those in the technical production function (α_1, α_2, α_3 *and* α_4). From equations (3.22) to (3.25) the values of γ_1; γ_2; γ_3 and γ_4 depend on the value of the curvature of the utility function (z) and the shares of parameters of factor inputs in the technical production function. Nevertheless, they are independent of the value of β and p, and thus do not depend on the specific regulatory regime in place.

Consider the factor share of labour in the institutional production function, γ_1. This must be smaller than α_1 in the 'technical' production function, since

$$\gamma_1 = \frac{z\alpha_1 - \alpha_1 - \alpha_2}{z - \alpha_1 - \alpha_2} < \alpha_1 . \qquad (4.33)$$

Taking the derivative of the value of γ_1 with respect to z gives

$$\frac{\partial(\gamma_1)}{\partial(z)} = \frac{(\alpha_1 + \alpha_2)(1-\alpha_1)}{(z-\alpha_1-\alpha_2)^2} > 0, \qquad (4.34)$$

so that the higher the disutility of effort, the higher the share parameter of labour in production.

Likewise, the factor share of land in the institutional production function will be greater than that in the 'technical' production function, or

$$\gamma_2 = \frac{z\alpha_2}{z-\alpha_1-\alpha_2} > \alpha_2 \qquad (4.35)$$

and the derivative of γ_2 with respect to z is

$$\frac{\partial(\gamma_2)}{\partial(z)} = \frac{-\alpha_2(\alpha_1+\alpha_2)}{(z-\alpha_1-\alpha_2)^2} < 0 \qquad (4.36)$$

so that the higher the disutility of effort, the lower the share parameter of land in production.

By symmetry it can also be proved that the factor share of current input expenditures in the institutional production function will be greater than that in the 'technical' production function, or $\gamma_3 > \alpha_3$ with

$$\frac{\partial(\gamma_3)}{\partial(z)} = \frac{-\alpha_3(\alpha_1 + \alpha_2)}{(z - \alpha_1 - \alpha_2)^2} < 0. \tag{4.37}$$

The factor share of physical capital in the institutional production function will be greater than that in the 'technical' production function, or $\gamma_4 > \alpha_4$ with

$$\frac{\partial(\gamma_4)}{\partial(z)} = \frac{-\alpha_4(\alpha_1 + \alpha_2)}{(z - \alpha_1 - \alpha_2)^2} < 0. \tag{4.38}$$

Under the same conditions, the change of the disutility coefficient z leads to changes in the share parameter of all factors of production. For example, if the disutility of effort increases, then the share of the labour parameter increases and the share of the parameters for land, current input and capital, decrease. Note that $\gamma_2 + \gamma_3 + \gamma_4 = 1 - \gamma_1$, so the total of the decrease in the parameters shares for land, current input expenditures, and capital, is equivalent to the increased amount of the share of the labour parameter.

4.5 Concluding remarks

This chapter has presented a formal analysis of the comparative statics effects on agricultural production of enhanced incentives and the different prices and market regimes that correspond to liberalisation across various transitional periods. Since prices and the structure of the goods and factor markets differ from one stage of trade liberalisation to the other, total factor productivity *(A)* and the farmer's optimal choice of effort $(\varepsilon_1, \varepsilon_2)$ also differ across various stages of reform. Indeed, for the most part this chapter strongly argues that total factor productivity and the farmer's optimal choice of effort have increased from the period of the communal system, to that of the output-contracts system, and from the output-contracts system to the period of the opening up or freeing of domestic and international markets. Quantitative estimation of the size of there effects for the case of rice production in Vietnam will be undertaken in Chapter 7.

Appendix 4A: THE CHANGE IN THE AVERAGE WEIGHTED COST-SHARE PARAMETER (*m*) FROM ONE STAGE OF TRADE LIBERALISATION TO THE NEXT[2]

Assume that from period 1 to period 2 the output price increased by a factor a ($a > 1$) and the input price increased by a factor x, so that

$$W^2(w_i) = (xw_3^1)^{\alpha_3} \quad \text{and } (\beta p)^2 = a(\beta p)^1. \tag{4A.1}$$

The average weighted-cost share parameter can increase only in the case

$$m_2 = \frac{x^{\alpha_3}}{a} m_1 > m_1 \qquad \text{or } x > a^{1/\alpha_3} \tag{4A.2}$$

If $\alpha_3 = 0.1$ as in the case of China (Tang (1980, p.28) or 22 LDC's (Hayami-Ruttan, 1985, chap 6), the average weighted-cost share parameter only increases if $x > a^{10}$. In general, it is not common for 4A.2 to occur. For example, if output price doubles (a =2), then m increases only if the price of fertiliser increases by 2^{10} or about 1000 times. In the case of paddy production in Vietnam, α_3 =0.2 (Appendix 7A) and since output price increases by a factor of 2.5 (Table DA.10, Data Appendix) m increases only if the price of fertiliser increases by a factor of 97.7. In fact, the price of fertiliser has decreased during trade liberalisation so the average weighted-cost share parameter has decreased from 0.31 (1976-80) to 0.23 (1994) (see Table DA.12, Data Appendix).

[2](The case of explicit payment refers only to current input expenditures)

Chapter 5

A DYNAMIC MODEL OF THE EFFECTS OF INTERNAL AND EXTERNAL TRADE LIBERALISATION ON AGRICULTURAL GROWTH

In Chapters 3 and 4 a static economic model was developed to show the positive effects on agricultural output of newly enhanced incentives in transitional economies. There, the analysis employed an institutional production function, which is derived from the underlying technical production function and captures the farmers' response to the institutional and market arrangements within which they work.

The specific form of the 'institutional production function' in a static model allows us to analyse how total factor productivity changes in response to liberalisation (see Chapter 4). However, the static model considers only the comparative static changes in total factor productivity and various output levels in the different stages of liberalisation thus abstracting from the potential dynamic effects associated with induced capital accumulation. In this chapter, we extend the static model to account for the long-run dynamic behaviour of agricultural output due to the effects of liberalisation, given the farmer's optimal intertemporal choice over his or her lifetime. The idea is to analyse the resulting optimal transitional paths and the new steady-state outcomes that are the result of the enhanced incentives to produce more, and more efficiently, in transitional economies. This will provide a model which is used in Chapter 8 to estimate the long-run effects of the different stages of liberalisation on the rice industry in Vietnam.

This chapter is organised as follows: Section 5.1 sets up and solves a dynamic optimal control problem for the representative farmer; one that accounts for the specific incentive effects of using land and labour more efficiently over time. To illustrate the solution, Section 5.2 constructs the appropriate phase diagram in the control-state-space for consumption and physical capital. Section 5.3 analyses how the relevant transitional dynamics change in different stages of trade liberalisation, while Section 5.4 characterises the positive effects of trade liberalisation on agricultural growth by comparing the outcomes in the growth model both with and without incentive effects. The chapter concludes in Section 5.5 with some overall remarks, and three appendices provide additional mathematical detail and derivations. Appendix 5A, in particular, derives the slope and the directions of motion around the stationary loci in the phase diagram in Section 5.2. As a specific basis for comparison, Appendices 5B and 5C construct a comparable and detailed growth model for the case where there are no incentive effects from trade liberalisation, and then compare the effects on the steady-state levels of the capital stock in both regimes.

5.1 A growth model for agriculture under the effects of internal and external trade liberalisation

For our purposes modern neoclassical growth theory starts with Ramsey (1928), with later developments given by Solow (1956), Swan (1956), Arrow (1962), Cass (1965), Koopmans (1965), and Sheshinski (1967). A central feature of these models (whether optimal or descriptive) is the assumption of an exogenous rate of growth in the labour force. Thus, changes in savings behaviour do not affect the steady-state growth rate, but only the steady-state values (for example) of consumption, output per capita and the stock of capital. In contrast, in the "new" class of endogenous growth models such as those of Romer (1986) and Lucas (1988), not only is the growth rate determined within the structure of the model but growth may go on indefinitely because the returns to investment of a broad class of capital goods-(ones which may include human capital) do not necessarily diminish as the economy develops. Spill-overs of knowledge across producers and the external benefits generated from the accumulation of human capital are also often part of this process, and help avoid the tendency for diminishing returns to the accumulation of capital (Barro and Sala-i-Martin, 1995).

Because this study is concerned with agricultural markets in which the production process is typically characterised by constant returns to scale with no significant spillovers, it is appropriate to use the neoclassical paradigm here. The growth rate of labour is exogenous but the standard neoclassical growth model is fully extended to account for the existence of incentive effects and the resulting economic change due to liberalisation. Of course there may also be a role for human capital accumulation,[1] however this is omitted here because of data limitations. Nevertheless, the analysis manages to capture most of the relevant effects of liberalisation on dynamic paths and the steady-state levels of consumption, output, the capital stock, and worker effort and efficiency.

For simplicity, assume that all farmers are identical and the farmer's utility is non-negative and a concave and increasing function of consumption, and that utility is negatively related to the optimal choice of effort involved in using labour and land more efficiently. At time t we assume the relationship between utility and the optimal choice of effort is given by

$$U = \frac{c(t)^{1-\sigma}}{1-\sigma} - \frac{\varepsilon_1(t)^z}{z\delta} - \frac{\varepsilon_2(t)^z}{z\delta} \tag{5.1}$$

where c represents consumption for the representative farmer; $\sigma \in (0,1) \cup (1,\infty)$ is the inverse of the constant intertemporal elasticity of substitution; $\delta > 0$ and $z > 1$ are constants as discussed in Chapter 3.

The representative farmer's problem is to maximise overall utility U over a lifetime by deciding how much should be consumed today (at any time t) or invested in capital to provide for consumption in the future and, in addition, what the correct or optimal trade-off should be between the effort required for higher income versus less effort or more leisure. In standard form, the dynamic optimal control problem for a representative farmer is thus given as

$$\text{Max} \int_0^\infty \left(\frac{c(t)^{1-\sigma}}{1-\sigma} - \frac{\varepsilon_1(t)^z}{z\delta} - \frac{\varepsilon_2(t)^z}{z\delta} \right) e^{-\rho t} dt \tag{5.2}$$

[1]The 'Solow residual' in the empirical work (see Section 7.2, Chapter 7), for example, may be due to the effects of human capital accumulation (among a great many other things).

subject to

$$\dot{k}_2(t) = I(t) - (\mu + n)k_2(t) \tag{5.3}$$

$$k_2(0) = k_2^0 \tag{5.4}$$

$$c(t) = \prod(t) - I(t) \tag{5.5}$$

where ρ is a constant subjective rate of time preference. The evolution of the stock of physical capital is given by equation (5.3) where a dot over a variable denotes (as usual) differentiation with respect to time. The value I represents investment and μ and n (both constants) represent the depreciation rate for physical capital and growth rate of the labour force respectively. The value of consumption $c(t)$ for a representative farmer is defined as the difference between the profit and investment at each time t.

Substituting the value of profit given by equation (3.14) adds a constraint for the control problem, or

$$c(t) = \beta p\left[(1 - C_0 m)q(t) - d\right] - I(t) \tag{5.6}$$

and substituting the value of q from equation (3.3) into (5.6), allows consumption c to be rewritten as

$$c(t) = \beta p(1 - C_0 m)\alpha_0 l^{\alpha_2} k_1^{\alpha_3} k_2^{\alpha_4} \varepsilon_1^{\alpha_1}(t)\varepsilon_2^{\alpha}(t) - \beta pd - I(t) \tag{5.7}$$

or

$$c(t) = B_3 k_2^{\alpha_4} \varepsilon_1^{\alpha_1}(t)\varepsilon_2^{\alpha}(t) - \beta pd - I(t) \tag{5.8}$$

where the value of B_3 is given by

$$B_3 = \beta p\left(1 - C_0 m\right)\alpha_0 l^{\alpha_2} k_1^{\alpha_3}. \tag{5.9}$$

Given the equality constraint, or equation (5.8), the current-value Hamiltonian for this problem is defined as

$$H = \left(\frac{c(t)^{1-\sigma}}{1-\sigma} - \frac{\varepsilon_1(t)^z}{z\delta} - \frac{\varepsilon_2(t)^z}{z\delta} \right) + \lambda(t)\left[\left(B_3 \varepsilon_1(t)^z \varepsilon_2(t)^z k_2^{\alpha_4} - \beta pd - I(t) - c(t) \right) \right]$$
$$+ \varphi(t)\left[I(t) - (\mu + n)k_2(t) \right] \tag{5.10}$$

The first-order necessary condition with respect to *c(t)*, or $\dfrac{\partial H}{\partial c(t)} = 0$ gives the result

$$c(t)^{-\sigma} = \lambda(t) \tag{5.11}$$

and the first order condition with respect to $\varepsilon_1(t)$, or $\dfrac{\partial H}{\partial \varepsilon_1(t)} = 0$ implies that

$$\varepsilon_1(t)^{z-\alpha_1} = \lambda(t) B_3 \delta \alpha_1 \varepsilon_2(t)^{\alpha_2} k_2(t)^{\alpha_4} . \tag{5.12}$$

By symmetry, the first order condition with respect to $\varepsilon_2(t)$, $\dfrac{\partial H}{\partial \varepsilon_2(t)} = 0$ gives

$$\varepsilon_2(t)^{z-\alpha_2} = \lambda(t) B_3 \delta \alpha_1 \varepsilon_1(t)^{\alpha_1} k_2(t)^{\alpha_4} \tag{5.13}$$

Taking the ratio of equations (5.13) to (5.12), and solving for the value of $\varepsilon_2(t)$ as a function of $\varepsilon_1(t)$ we get

$$\varepsilon_2(t) = \varepsilon_1(t) \left(\frac{\alpha_2}{\alpha_1} \right)^{1/z} \tag{5.14}$$

as in the static model (see Chapter 3).

The first order condition with respect to *I(t)*, $\dfrac{\partial H}{\partial I(t)} = 0$ gives

$$\lambda(t) = \varphi(t) \tag{5.15}$$

and the co-state and state variables satisfy the conditions

$$\dot{\varphi}(t) = -\frac{\partial H}{\partial k_2(t)} + \rho \varphi(t)$$

or

$$\dot{\varphi} = -\lambda(t) B_3 \alpha_4 \varepsilon_1(t)^{\alpha_1} \varepsilon_2(t)^{\alpha_2} k_2^{\alpha_4 - 1} + \varphi(t)(\mu + n + \rho) \tag{5.16}$$

and

$$\dot{k}_2(t) = \frac{\partial H}{\partial \varphi} = I(t) - (\mu + n) k_2(t) \tag{5.17}$$

with the initial condition given as in (5.4) and

$$\lim_{t \to \infty} \left[\varphi(t) k_2(t) \right] = 0 \tag{5.18}$$

as the transversality condition.

5.2 Phase diagram analysis

The above application of the 'Maximum Principle' yields a set of first-order necessary conditions including a pair of differential equations in $\varphi(t)$ and $k_2(t)$. It is difficult to solve the system directly or explicitly (although see Chapter 8 for a further, applied analysis), but the solution can be nicely characterised with a phase diagram in the space for c and k_2. The various regions designate optimal motions of the variables over time and define a steady-state. We first find the appropriate differential equations for consumption and the physical capital stock.

(a) The differential equation for consumption (c) in terms of c and k_2

Substituting equation (5.14) into (5.12) and solving for the value of $\varepsilon_1(t)$ gives

$$\varepsilon_1(t) = \left[\lambda(t) \delta B_3 (\alpha_1)^{\frac{z - \alpha_2}{z}} (\alpha_2)^{\frac{\alpha_2}{z}} k_2(t)^{\alpha_4} \right]^{\frac{1}{z - \alpha_1 - \alpha_2}} \tag{5.19}$$

and using the results in (5.14) and (5.19) we can obtain

$$\varepsilon_1(t)^{\alpha_1}\varepsilon_2(t)^{\alpha_2}=\lambda(t)^{\frac{\alpha_1+\alpha_2}{z-\alpha_1-\alpha_2}}\delta^{\frac{\alpha_1+\alpha_2}{z-\alpha_1-\alpha_2}}B_3^{\frac{\alpha_1+\alpha_2}{z-\alpha_1-\alpha_2}}\alpha_1^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}}\alpha_2^{\frac{\alpha_2}{z-\alpha_1-\alpha_2}}k_2(t)^{\frac{\alpha_4}{z-\alpha_1-\alpha_2}}. \quad (5.20)$$

Substituting equation (5.20) into (5.16), gives a differential equation for the co-state (or shadow) price of physical capital, so that

$$\dot{\varphi}(t)=-\lambda(t)^{\frac{z}{z-\alpha_1-\alpha_2}}\delta^{\frac{\alpha_1+\alpha_2}{z-\alpha_1-\alpha_2}}B_3^{\frac{z}{z-\alpha_1-\alpha_2}}\alpha_1^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}}\alpha_2^{\frac{\alpha_2}{z-\alpha_1-\alpha_2}}\alpha_4 k_2(t)^{\frac{z\alpha_4}{z-\alpha_1-\alpha_2}-1}+\varphi(t)(\mu+n+\rho)$$

or

$$\dot{\varphi}(t)=-\lambda(t)^{\frac{z}{z-\alpha_1-\alpha_2}}B_4\alpha_4 k_2(t)^{\frac{z\alpha_4}{z-\alpha_1-\alpha_2}-1}+\varphi(t)(\mu+n+\rho) \quad (5.21)$$

where

$$B_4=\delta^{\frac{\alpha_1+\alpha_2}{z-\alpha_1-\alpha_2}}B_3^{\frac{z}{z-\alpha_1-\alpha_2}}\alpha_1^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}}\alpha_2^{\frac{\alpha_2}{z-\alpha_1-\alpha_2}}. \quad (5.22)$$

From the results in (5.11) and (5.15) it follows that

$$\varphi(t)=\lambda(t)=c(t)^{-\sigma} \quad (5.23)$$

and differentiating (5.23) with respect to time yields

$$\dot{\varphi}(t)=(-\sigma)c(t)^{-\sigma-1}\dot{c}(t). \quad (5.24)$$

Finally, substituting equations (5.23) and (5.24) into (5.21) and solving gives

$$\dot{c}(t)=\frac{1}{\sigma}\left[c(t)^{\frac{-\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}+1}B_4\alpha_4 k_2(t)^{\frac{z\alpha_4}{z-\alpha_1-\alpha_2}-1}\right]-\frac{1}{\sigma}c(t)(\mu+n+\rho) \quad (5.25)$$

or the desired differential equation in consumption *(c)* in terms of c and k_2 only.

Note that the differential equation in consumption *(c)* in this model is different from the more standard Ramsey model without incentive effects (see Appendix 5B). In this case, the marginal product of capital in the steady-state is not equal to just the sum of the rate of time preference, the rate of depreciation of capital and the growth rate of labour force. Instead, the marginal product of capital in the steady-state also depends on the inverse of the constant intertemporal elasticity of substitution, the disutility of effort, and consumption at that time.

(b) The differential equation for physical capital (k_2) in terms of c and k_2

Begin by substituting the value of $I(t)$ given in equation (5.17) into equation (5.8) so that

$$c(t) = B_3 k_2^{\alpha_4} \varepsilon_1^{\alpha_1}(t) \varepsilon_2^{\alpha}(t) - \beta pd - \dot{k}_2(t) - (\mu + n)k_2(t) \tag{5.26}$$

or

$$\dot{k}_2(t) = B_3 k_2^{\alpha_4} \varepsilon_1^{\alpha_1}(t) \varepsilon_2^{\alpha}(t) - \beta pd - (\mu + n)k_2(t) - c(t) \tag{5.27}$$

The value of $\varepsilon_1(t)$ and $\varepsilon_2(t)$ in equation (5.27) can be eliminated by substituting from (5.20), giving

$$\dot{k}_2(t) = \lambda(t)^{\frac{z}{z-\alpha_1-\alpha_2}} \delta^{\frac{\alpha_1+\alpha_2}{z-\alpha_1-\alpha_2}} B_3^{\frac{z}{z-\alpha_1-\alpha_2}} \alpha_1^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}} \alpha_2^{\frac{\alpha_2}{z-\alpha_1-\alpha_2}} \alpha_4 k_2(t)^{\frac{z\alpha_4}{z-\alpha_1-\alpha_2}}$$
$$-(\mu+n)k_2(t) - c(t) - \beta pd \tag{5.28}$$

and by substituting (5.11) into (5.28), using the definition of B_4 in (5.22), we can obtain the differential equation in physical capital involving c and k_2 only, or

$$\dot{k}_2(t) = c(t)^{\frac{-\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}} B_4 k_2(t)^{\frac{z\alpha_4}{z-\alpha_1-\alpha_2}} - (\mu+n)k_2(t) - c(t) - \beta pd\,. \tag{5.29}$$

As in the case of consumption, and as will be discussed later, the differential equation in physical capital (k_2) in the growth model with incentive effects (resulting from liberalisation) also differs with that in the model without incentive effects.

(c) The phase diagram for the optimal control problem

The phase diagram is constructed from considering the differential equations in consumption *(c)* and capital (k_2) simultaneously (or equations (5.25) and (5.29)), listed here again for convenience:

$$\dot{c}(t)=\frac{1}{\sigma}\left[c(t)^{\frac{-\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}+1}B_4\alpha_4 k_2(t)^{\frac{z\alpha_4}{z-\alpha_1-\alpha_2}-1}\right]-\frac{1}{\sigma}c(t)(\mu+n+\rho) \tag{5.25}$$

$$\dot{k}_2(t)=c(t)^{\frac{-\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}B_4 k_2(t)^{\frac{z\alpha_4}{z-\alpha_1-\alpha_2}}-(\mu+n)k_2(t)-c(t)-\beta pd\,. \tag{5.29}$$

To complete the exercise it is first necessary to graph the two stationary loci for $\dot{c}=0$ and $\dot{k}_2=0$. This is done in Figure 5.1 (see Appendix 5A for the derivation of the relevant slopes and directions of motion).

Given the curvature of $\dot{c}$ and $\dot{k}_2$, the two stationary loci may intersect each other at two points. However, in the case (if it exists), where $\dot{k}_2$ intersects $\dot{c}$ from above, it can be shown that this must occur at very large value of k_2.[2] Based on boundary conditions, we can ignore this equilibrium and focus on the first case, or the steady-state equilibrium designated by point *E* in Figure 5.1. The phase-space is thus divided into four distinct regions (I through IV), and at point *E* the values of k_2^*, and c^* are stationary. At any other point, either k_2 or c changes in the directions indicated by the sign of the derivatives of $\dot{c}$ and $\dot{k}_2$, with respect to c and k_2 respectively, at that point. The result is indicated in Figure 5.1, with directions of motion (and the resulting trajectories) in all regions as shown (see Appendix 5A).

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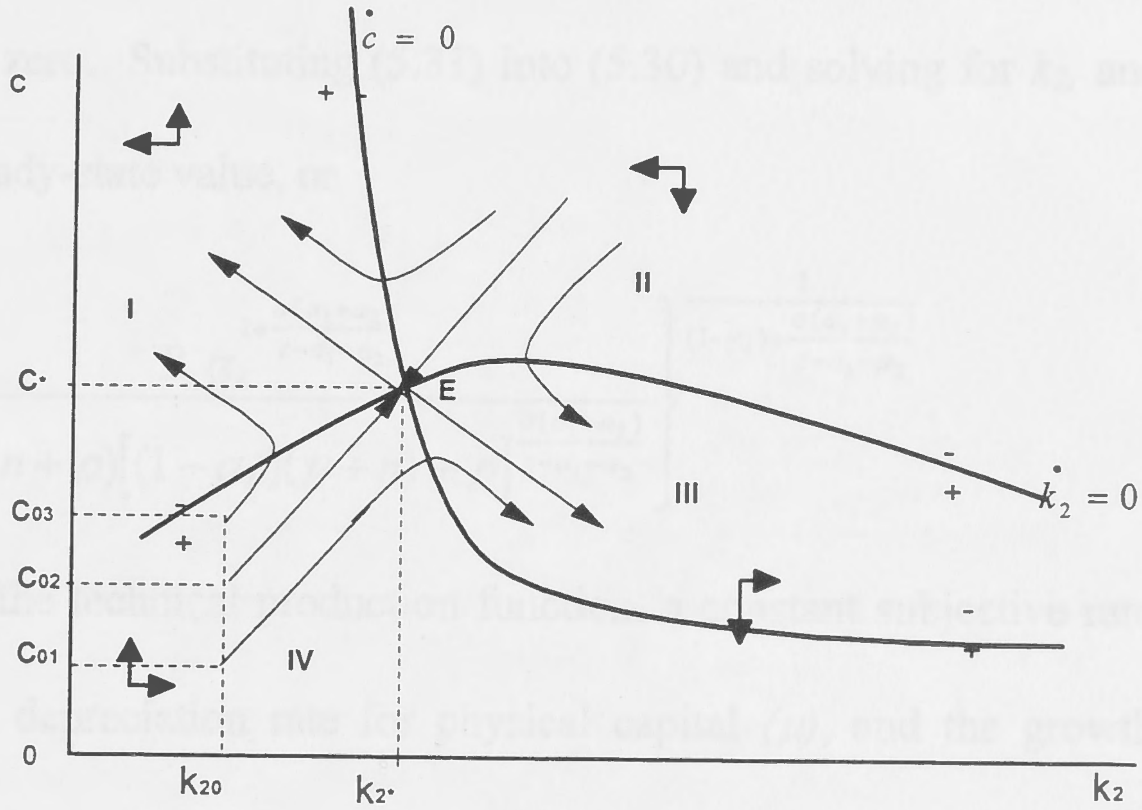
[2] From Appendix 5A, it can be shown that the locus of points for which $\dot{c}=0$ is very steep so that the second equilibrium (if it exists) is at very large value of k_2.

Figure 5.1: **The phase diagram for a dynamic model of the effects of internal and external trade liberalisation**



The equilibrium E is seen to be a saddlepoint. For any initial value of *k(0)* (say k_o) less than k_2^* there is only one initial value of c at time zero (say c_0^2 as in Figure 5.1) that gives an optimal equilibrium path that converges to point E. All other paths diverge. Along this path both the values of c and k increase to their steady-state values.

5.3 The effects of different stages of internal and external trade liberalisation on steady-state equilibrium

With enhanced incentive effects in mind, is now easy to analyse the effects of liberalisation on the steady-state values of c^* and k_2^*. When $\dot{c} = \dot{k}_2 = 0$, from equation (5.25), we obtain

$$\left[B_4 c(t)^{\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}} \alpha_4 k_2^{\frac{z\alpha_4}{z-\alpha_1-\alpha_2}-1} = (\rho + \mu + n) \right]. \qquad (5.30)$$

Substituting (5.30) into (5.29) and solving for consumption c as a function of k_2 gives

$$c^* = k_2^* \left[\frac{\rho + (1-\alpha_4)(\mu + n)}{\alpha_4} \right] - \beta p d . \tag{5.31}$$

For convenience and in order to simplify the solution, we ignore d in equation (5.31) and set it equal to zero. Substituting (5.31) into (5.30) and solving for k_2, and c gives the equilibrium steady-state value, or

$$k_2^* = \left\{ \frac{B_4 \alpha_4^{\,1+\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}}{(\mu+n+\rho)\left[(1-\alpha_4)(\mu+n)+\rho\right]^{\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}} \right\}^{\frac{1}{(1-\gamma_4)+\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}} . \tag{5.32}$$

Given the form of the technical production function, a constant subjective rate of time preference *(ρ)*, the depreciation rate for physical capital *(μ)*, and the growth rate of labour force *(n)*, the steady-state values of physical capital and consumption depend only on the value of B_3 or $\beta p(1-C_0 m)$. Under different stages of liberalisation this value will change.

As discussed in Chapter 4 above, liberalisation provides direct effects in the goods and factor markets. The changes in the structure of goods and factor markets, the changes in the price of goods, and the relative price of inputs and outputs causes the value of $\beta p(1-C_0 m)$ to vary in the different stages of liberalisation, so the steady-state values of physical capital and consumption also vary.

(a) In the communal system

Substituting the value of p_S, and β (given by (4.2) where $\beta_0^C = 1; \beta_1^C = 0; \beta_2^C = 0$), the value of m (see Section 4.1, Chapter 4) and the value of B_3 and B_4 (given as in (5.9) and

(5.22) respectively) into (5.31) and (5.32), we get the steady-state values of physical capital (k_2^0) and consumption (c^*), which are

$$k_2^0 = \left\{ \frac{(p_s(1-C_0 m_c)\alpha_0 l^{\alpha_2} k_1^{\alpha_3})^{\frac{z}{z-\alpha_1-\alpha_2}} \delta^{\frac{\alpha_1+\alpha_2}{z-\alpha_1-\alpha_2}} \alpha_1^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}} \alpha_2^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}} \alpha_4^{1+\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}}{(\mu+n+\rho)\left[(1-\alpha_4)(\mu+n)+\rho\right]^{\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}} \right\}^{\frac{1}{(1-\gamma_4)+\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}} \tag{5.33}$$

and

$$c^* = \left\{ \frac{(p_s(1-C_0 m_c)\alpha_0 l^{\alpha_2} k_1^{\alpha_3})^{\frac{z}{z-\alpha_1-\alpha_2}} \delta^{\frac{\alpha_1+\alpha_2}{z-\alpha_1-\alpha_2}} \alpha_1^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}} \alpha_2^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}} \alpha_4^{1+\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}}{(\mu+n+\rho)\left[(1-\alpha_4)(\mu+n)+\rho\right]^{\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}} \right\}^{\frac{1}{(1-\gamma_4)+\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}}$$

$$\left[\frac{\rho(1-\alpha_4)(\mu+n)}{\alpha_4}\right] - p_s d. \tag{5.34}$$

(b) In the period of output contracts with a tight domestic market

The value of p_S and β are given by equation (4.3) where $1>\beta_0^D>0; 1>\beta_1^D>0; \beta_2^D=0; \beta_0^D+\beta_1^D=1$, with β_1^D being very small (see Section 4.1, Chapter 4). By symmetry, from (5.31) and (5.32) we get of the steady-state value of physical capital (k_2^I) and consumption (c^I) as

$$k_2^I = \left\{ \frac{\left[(\beta_0^D p_s + \beta_1^D p_M)(1-C_0 m_D)\alpha_0 l^{\alpha_2} k_1^{\alpha_3} \right]^{\frac{z}{z-\alpha_1-\alpha_2}} \delta^{\frac{\alpha_1+\alpha_2}{z-\alpha_1-\alpha_2}} \alpha_1^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}} \alpha_2^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}} \alpha_4^{1+\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}}{(\mu+n+\rho)\left[(1-\alpha_4)(\mu+n)+\rho\right]^{\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}} \right\}^{\frac{1}{(1-\gamma_4)+\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}} \tag{5.35}$$

and

$$c^{II} = \left\{ \frac{\left[(\beta_0^D p_s + \beta_1^D p_M)(1-C_0 m_D)\alpha_0 l^{\alpha_2} k_1^{\alpha_3} \right]^{\frac{z}{z-\alpha_1-\alpha_2}} \delta^{\frac{\alpha_1+\alpha_2}{z-\alpha_1-\alpha_2}} \alpha_1^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}} \alpha_2^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}} \alpha_4^{1+\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}}{(\mu+n+\rho)\left[(1-\alpha_4)(\mu+n)+\rho\right]^{\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}} \right\}^{\frac{1}{(1-\gamma_4)+\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}}$$

$$\left[\frac{\rho(1+\alpha_4)(\mu+n)}{\alpha_4} \right] - (\beta_0^D p_s + \beta_1^D p_M) d . \tag{5.36}$$

(c) In the period of full freedom in the domestic market

Substituting the value of p_M and β (given by (4.4) where $\beta_0^M = 0; \beta_1^M = 1; \beta_2^M = 0$, as in Section 4.1, Chapter 4), by symmetry, we get the value of the steady state for physical capital (k_2^{II}) and consumption (c^{II}) as

$$k_2^{II} = \left\{ \frac{(p_M (1 - C_0 m_M)\alpha_0 l^{\alpha_2} k_1^{\alpha_3})^{\frac{z}{z-\alpha_1-\alpha_2}} \delta^{\frac{\alpha_1+\alpha_2}{z-\alpha_1-\alpha_2}} \alpha_1^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}} \alpha_2^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}} \alpha_4^{1+\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}}{(\mu + n + \rho)\left[(1 - \alpha_4)(\mu + n) + \rho\right]^{\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}} \right\}^{\frac{1}{(1-\gamma_4)+\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}} \tag{5.37}$$

and

$$c^{II} = \left\{ \frac{(p_s (1 - C_0 m_M)\alpha_0 l^{\alpha_2} k_1^{\alpha_3})^{\frac{z}{z-\alpha_1-\alpha_2}} \delta^{\frac{\alpha_1+\alpha_2}{z-\alpha_1-\alpha_2}} \alpha_1^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}} \alpha_2^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}} \alpha_4^{1+\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}}{(\mu + n + \rho)\left[(1 - \alpha_4)(\mu + n) + \rho\right]^{\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}} \right\}^{\frac{1}{(1-\gamma_4)+\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}}$$

$$\left[\frac{\rho(1 - \alpha_4)(\mu + n)}{\alpha_4} \right] - p_s d . \tag{5.38}$$

(d) In the period of opening up the international market

From the value of β given by (4.5) where $\beta_0^W = 0; 1 > \beta_1^W > 0; 1 > \beta_2^W > 0; \beta_1^W + \beta_2^W = 1$ (Section 4.1, Chapter 4), once again, by symmetry, the value of the steady state for physical capital (k_2^{III}) and consumption (c^{III}) are given by

$$k_2^{III} = \left\{ \frac{\left[(\beta_1^W p_M + \beta_2^W p_W)(1 - C_0 m_W)\alpha_0 l^{\alpha_2} k_1^{\alpha_3} \right]^{\frac{z}{z-\alpha_1-\alpha_2}} \delta^{\frac{\alpha_1+\alpha_2}{z-\alpha_1-\alpha_2}} \alpha_1^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}} \alpha_2^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}} \alpha_4^{1+\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}}{(\mu+n+\rho)\left[(1-\alpha_4)(\mu+n)+\rho\right]^{\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}} \right\}^{\frac{1}{(1-\gamma_4)+\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}} \tag{5.39}$$

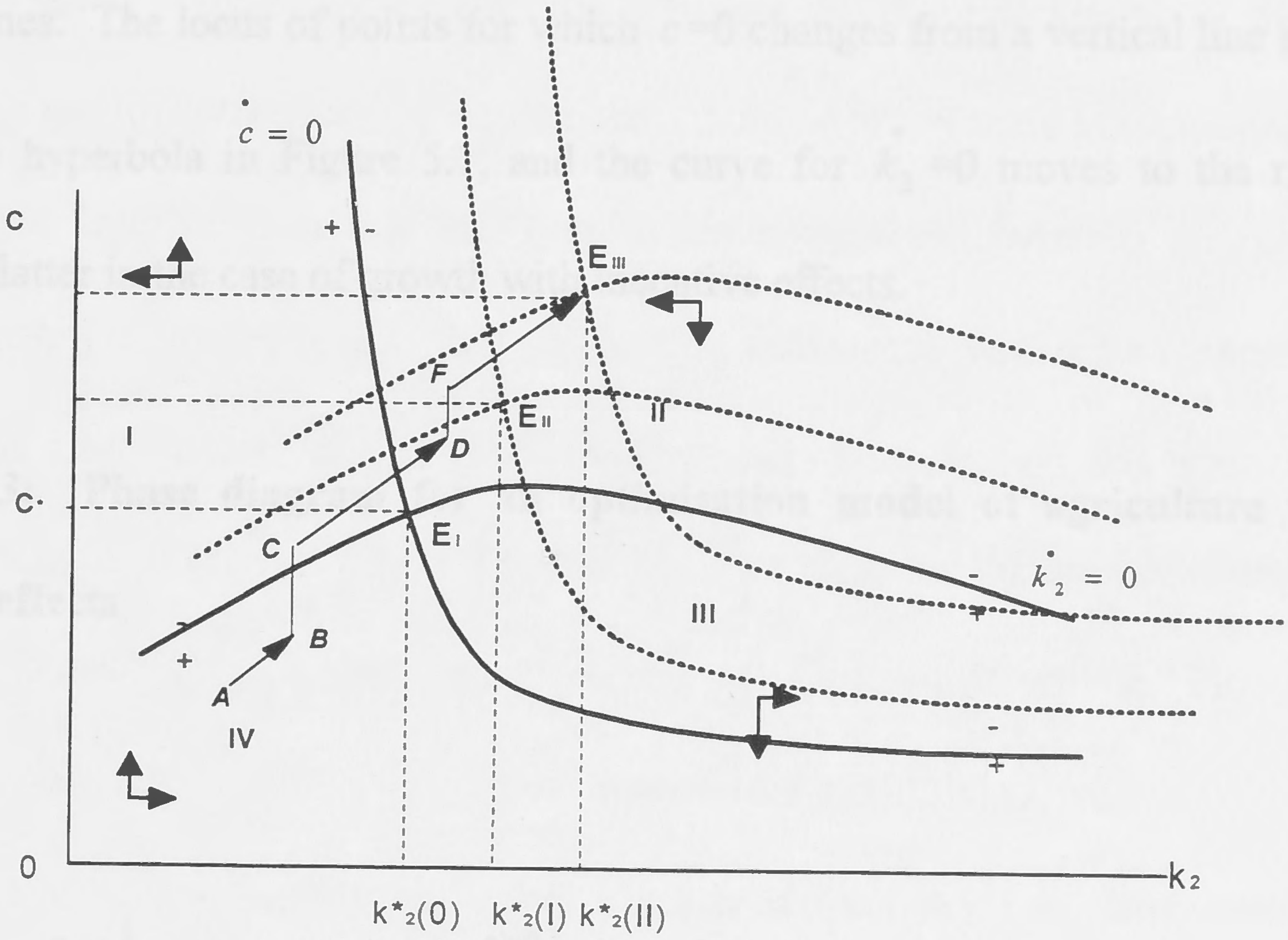
and

$$c^{II} = \left\{ \frac{\left[(\beta_1^W p_M + \beta_1^W p_W)(1 - C_0 m_W)\alpha_0 l^{\alpha_2} k_1^{\alpha_3} \right]^{\frac{z}{z-\alpha_1-\alpha_2}} \delta^{\frac{\alpha_1+\alpha_2}{z-\alpha_1-\alpha_2}} \alpha_1^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}} \alpha_2^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}} \alpha_4^{1+\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}}{(\mu+n+\rho)\left[(1-\alpha_4)(\mu+n)+\rho\right]^{\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}} \right\}^{\frac{1}{(1-\gamma_4)+\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}}$$
$$\left[\frac{\rho(1+\alpha_4)(\mu+n)}{\alpha_4}\right] - (\beta_1^W p_M + \beta_1^W p_W)d \tag{5.40}$$

In Chapter 4 (see Sections 4.1 and 4.2) it was argued that, in the majority of cases in transitional economies, goods markets develop earlier and faster than factor markets. In that case, the value $\beta p(1 - C_0 m)$ will increase since βp will increase regardless of whether m falls (if in fact it does) with trade liberalisation, and indeed the empirical work for Vietnam is clearly consistent with that assumption. On that basis and from equations (5.33) through (5.40), it can be seen that as $\beta p(1 - C_0 m)$ increases, so do k_2^* and c^* (see Figure 5.2).

In the phase diagram in Figure 5.2, an increase in $\beta p(1 - C_0 m)$ causes the locus $\dot{c}$=0 to shift up and to the right, and the $\dot{k}_2$ =0 curve to also shift up. Different steady-state equilibria are obtained for each different period of trade liberalisation. In Figure 5.2, the equilibria E^I, E^{II} and E^{III} represent the equilibria in the period of output contracts with a tight domestic market, the period of full freedom in the domestic market and the period of the opening up of the international market respectively. With each new stage of liberalisation, the economic system jumps up onto a new higher transitional path, thus following the path *ABCF* to the final steady state E_{III}.

Figure 5.2: **The transitional and steady-state effects of the different stages of trade liberalisation**



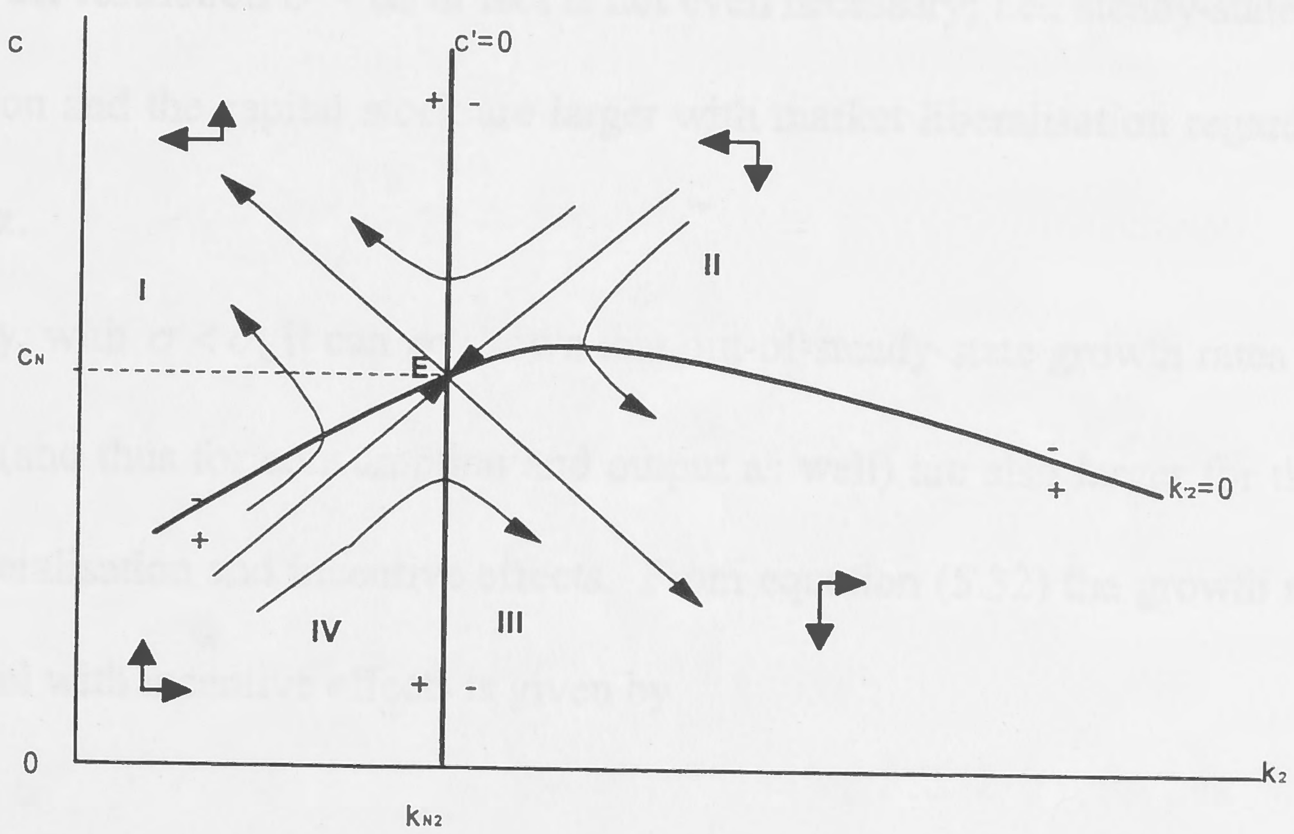
The broad conclusions of this analysis are straight forward. Based on analysis in this section, it is clear that liberalisation results in both enhanced path effects and larger steady-state values of consumption and physical capital. This will be explored further in the empirical analysis of Chapter 8.

5.4 The role of incentive effects on agricultural growth

The effects of trade liberalisation include not only changes in the structure of the market and changes in prevailing prices, but also induced changes in worker effort and efficiency. This section considers the role of such "incentive effects" of liberalisation by comparing a growth model including incentive effects with one where such effects are absent. The two cases are compared in terms of the differences in their underlying transitional dynamics and their resulting steady-states.

A quick comparison of the phase diagrams in Figure 5.1 above and Figure 5.3 for the case without incentive effects[3], gives a general overview of the differences in both regimes. The locus of points for which $\dot{c}=0$ changes from a vertical line in Figure 5.3 to the hyperbola in Figure 5.1, and the curve for $\dot{k}_2=0$ moves to the right and becomes flatter in the case of growth with incentive effects.

Figure 5.3: **Phase diagram for an optimisation model of agriculture without incentive effects**



[3] For the details of this model (without incentive effects) and the construction of the phase diagram, see Appendix 5B.

Moreover, based on equations (5.31), (5.32), and equations (5B.17), (5B.24) (see Appendix 5B), we can also directly compare the steady-state levels of consumption and physical capital in both cases. It is clear that with trade liberalisation, in the presence of incentive effects, all other things equal, the steady-state for consumption and physical capital is greater, provided that $\sigma < \alpha_4$; i.e., for the case in which the constant intertemporal elasticity of consumption is less than the share parameter of the capital input in the production function (see Appendix 5C). *A priori* there is no way to restrict the value of σ other than the fact that it lies somewhere between zero and one. Nevertheless, a lower value of σ implies that the representative farmer is more willing to postpone consumption in response to higher rates of return, and this seems a likely scenario for emerging or transitional economies first experiencing market liberalisation, with their accompanying higher returns and bursts of economic growth.[4] In any case, the correct value for σ is an empirical matter and preliminary work in this regard suggests that the restriction $\sigma < \alpha_4$ in fact is not even necessary; i.e., steady-state values of consumption and the capital stock are larger with market liberalisation regardless of the value of σ..

Finally, with $\sigma < \alpha_4$ it can be shown that out-of-steady-state growth rates for the capital stock (and thus for consumption and output as well) are also larger for the case with trade liberalisation and incentive effects. From equation (5.32) the growth rate for physical capital with incentive effects is given by

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[4] If $\sigma > \alpha_4$ it implies that trade liberalisation and enhanced incentive effects result in *lower* steady-state values of consumption and the capital stock in the model and, as we will see shortly in the paper, *lower* out-of-steady-state values for the growth rate of the capital stock, and this seems contrary to experience. For growth rates, a similar parameter restriction matters for standard Ramsey models without incentive effects (see Barro and Sala-i-Martin, p.59-95, 1995).

$$\frac{\dot{k}_2^*}{k_2^*} = \frac{z}{z-\alpha_1-\alpha_2}\left[\frac{1}{(1-\gamma_4)+\dfrac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}\right](\frac{\beta p(1-\dot{C_0}m)}{\beta p(1-C_0m)} \tag{5.41}$$

and from equation (5B.17) in Appendix 5B, the comparable growth rate for physical capital without incentive effects is

$$\frac{\dot{k}_2^N}{k_2^N} = \frac{1}{1-\alpha_4}\frac{\left[\beta p(1-\dot{C_0}m)\right]}{\left[\beta p(1-C_0m)\right]}. \tag{5.42}$$

It can be seen by comparing (5.41) and (5.42) that with the same growth rate of $\beta p(1-C_0m)$, the growth rate of physical capital with incentive effects is greater than that without incentive effects. Subsequent empirical work (see Chapter 7) will estimate the size of these dynamic effects.

5.5 Concluding remarks

This chapter extends the static model of Chapters 3 and 4 by developing a dynamic optimal control model to show the effects on agricultural output and the steady-state capital-labour ratio that result from changes in prices, market arrangements, and the enhanced incentives due to the process of liberalisation. In a given trade regime, the farmer's problem is to maximise utility over a given time horizon by deciding, on the one hand, how much should be consumed today (at any time *t*) or invested for tomorrow, and, on the other, by determining what the correct or optimal trade off should be between the effort required for higher income versus less effort or more leisure.

Based on the analysis of this chapter, most importantly, it is clearly seen that liberalisation results in enhanced path and steady-state effects. Indeed, a direct comparison between a growth model with incentive effects, and one without, in terms of the differences in their underlying transitional dynamics and their resulting steady-states, shows that with the presence of incentive effects the steady-state values for consumption and physical capital are greater, and certainly so in the case for which the constant intertemporal elasticity of consumption is less than the share parameter of the capital input in the production function.

Appendix 5A: THE CHARACTERISTICS OF THE LOCUS OF POINTS WHERE $\dot{c}=0$ AND $\dot{k}_2=0$, WITH INCENTIVE EFFECTS

(a) **The slope of the curve of points where** $\dot{c}=0$**:** Dividing (5.25) by c (assuming that c is greater than zero), implies that locus of points where $\dot{c}=0$ is given by the graph of the equation

$$\left[B_4\alpha_4 c(t)^{\frac{-\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}\, k_2(t)^{\frac{z\alpha_4}{z-\alpha_1-\alpha_2}-1}\right]-(\mu+n+\rho)=0\,. \tag{5A.1}$$

Because equation (5.14) satisfies the condition for the static model at any different time t, it is possible to substitute $\gamma_4=\dfrac{z\alpha_4}{z-\alpha_1-\alpha_2}$ into (5A.1), where γ_4 is the share parameter of physical capital in the institutional production function. Totally differentiating equation (5A.1) with respect to c and k_2, gives

$$\left.\frac{dc}{dk_2}\right|_{\dot{c}=0}=\frac{c}{k_2}\frac{\overbrace{(\gamma_4-1)(z-\alpha_1-\alpha_2)}^{-}}{\underbrace{\sigma(\alpha_1+\alpha_2)}_{+}}\,. \tag{5A.2}$$

In the space (c, k_2), the value of $\left.\dfrac{dc}{dk_2}\right|_{\dot{c}=0}$ has a negative sign, and the second derivative $\left.\dfrac{d^2c}{dk_2{}^2}\right|_{\dot{c}=0}$ is positive, so that the locus $\dot{c}=0$ has a convex shape. It also is noted that

$$\lim_{c\to\infty}k_2\Big|_{\dot{c}=0}=\lim_{k_2\to\infty}c\Big|_{\dot{c}=0}=0 \tag{5A.3}$$

The result is shown in Figure 5.1.

(b) The slope of the curve of points where $\dot{k}_2$ **=*0*:** Equation (5.29) implies that

$$c(t)^{\frac{-\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}\,B_4k_2(t)^{\frac{z\alpha_4}{z-\alpha_1-\alpha_2}}-(\mu+n)k_2(t)-c(t)-\beta pd=0\,. \tag{5A.4}$$

Once again, substituting $\gamma_4 = \dfrac{z\alpha_4}{z-\alpha_1-\alpha_2}$, and totally differentiating (5A.4) with respect to k_2.

gives

$$\left.\frac{dc}{dk_2}\right|_{\dot{k}_2=0} = \frac{\gamma_4 B_4 c^{-\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}} k_2^{\gamma_4-1} - (\mu+n)}{\dfrac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2} B_4 c^{-\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}-1} k_2^{\gamma_4} + 1}. \tag{5A.5}$$

Because the sign of the denominator is positive, the sign of (5A.5) depends on the sign of the numerator. Rewriting the numerator of (5A.5), given the definitions of B_3 and B_4 in equations (5.9) and (5.22), yields

$$\left[\ \beta p(1-C_0 m)\alpha_0 l^{\alpha_2} k_1^{\alpha_3}\ \right]^{\frac{z}{z-\alpha_1-\alpha_2}} \delta^{\frac{\alpha_1+\alpha_2}{z-\alpha_1-\alpha_2}} \alpha_1^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}} \alpha_2^{\frac{\alpha_2}{z-\alpha_1-\alpha_2}} \gamma_4 c^{-\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}} k_2^{\gamma_4-1} - (\mu+n). \tag{5A.6}$$

Substituting the value of total factor productivity and the factor share for land and current inputs in the static 'institutional production function' at time t into (5A.5), implies that

$$\left.\frac{dc}{dk_2}\right|_{\dot{k}_2=0} = \frac{\beta p(1-C_0 m) c^{-\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}} \dfrac{\partial(q^S)}{\partial k_2} - (\mu+n)}{\dfrac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2} B_4 c^{-\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}-1} k_2^{\gamma_4} + 1} \tag{5A.7}$$

where q^S is the institutional production function. It can be shown that if the production function is neoclassical, then the institutional production function is also exhibits: (i) a positive and diminishing marginal product with respect to physical capital; (ii) constant returns to scale (as proved in Chapter 3); and (iii) satisfies all Inada conditions (Inada, 1963). In particular,

$$\frac{\partial q}{\partial k_2} > 0 \qquad \frac{\partial^2 q}{\partial k_2^{\,2}} < 0 \tag{5A.8}$$

and

$$\lim_{k_2\to 0}\frac{\partial q}{\partial k_2} = \infty \qquad \lim_{k_2\to\infty}\frac{\partial q}{\partial k_2} = 0. \tag{5A.9}$$

With this in mind, the sign of $\left.\dfrac{dc}{dk_2}\right|_{\dot{k}_2=0}$ can be determined from conditions (5A.8) and (5A.9).

The value $\left.\dfrac{dc}{dk_2}\right|_{\dot{k}_2=0}$ is positive and decreases from a large value when k_2 rises from an extremely low level to some higher level; $\left.\dfrac{dc}{dk_2}\right|_{\dot{k}_2=0}$ equals zero when k_2 increases to a specific value large enough to make $\beta p(1-C_0 m)\dfrac{\partial q}{\partial k_2}$ equal to $(\mu+n)$; and $\left.\dfrac{dc}{dk_2}\right|_{\dot{k}_2=0}$ turns negative and decreases when k_2 continues to increase even further. Therefore, the shape of the $\dot{k}_2=0$ locus is concave as indicated in Figure 5.1.

c) The motion of the curves $\dot{c}=0$ and $\dot{k}_2=0$: The variation of $\dot{c}$ with respect to c in equation (5.25) is given by

$$\frac{\partial \dot{c}}{\partial c}=\frac{1}{\sigma}\left[\left(-\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}\right)B_4 c(t)^{-\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}\alpha_4 k_2^{\frac{z\alpha_4}{z-\alpha_1-\alpha_2}-1}-(\rho+\mu+n)\right] \quad (5A.10)$$

and implies that $\dfrac{\partial \dot{c}}{\partial c}<0$, whereas the variation of $\dot{k}_2$ with respect to k in equation (5A.1) is given by

$$\frac{\partial \dot{k}_2}{\partial k_2}=c(t)^{-\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}\gamma_4 B_4 k_2^{\gamma_4-1}-(\mu+n)\,. \quad (5A.11)$$

It is noted that the value of $\dfrac{\partial \dot{k}_2}{\partial k_2}$ is the same sign as is the numerator of $\left.\dfrac{dc}{dk_2}\right|_{\dot{k}_2=0}$ in equation (5A.5).

Appendix 5B: A GROWTH MODEL FOR AGRICULTURE WITHOUT THE INCENTIVE EFFECTS OF TRADE LIBERALISATION

As a comparison to the model presented in Chapter 5 above, consider a comparable system without the incentive effects of trade liberalisation; i.e., a system that resembles a more standard Ramsey model. All definitions and notation are as in the paper. Assume that the agricultural production function exhibits constant returns to scale, so production at time t is given by

$$Q = \alpha_0 (N)^{\alpha_1} (L)^{\alpha_2} (K_1)^{\alpha_3} (K_2)^{\alpha_4} . \tag{5B.1}$$

The quantity produced by a representative farmer q is thus

$$q = \alpha_0 (l)^{\alpha_2} (k_1)^{\alpha_3} (k_2)^{\alpha_4} . \tag{5B.2}$$

By symmetry with the derivation given in the static model, the profit function is given as

$$\Pi = \beta p [\ q(1 - C_0 m) - d\ ]. \tag{5B.3}$$

Assume that each farmer wishes to maximise overall utility U, given by

$$U = \int_0^\infty \left(\frac{c(t)^{1-\sigma}}{1-\sigma} \right) e^{-\rho t} dt \tag{5B.4}$$

subject to

$$\dot{k}_2(t) = I(t) - (\mu + n) k_2(t) \tag{5B.5}$$

$$k_2(0) = k(0) \tag{5B.6}$$

and

$$c(t) = \Pi(t) - I(t) \tag{5B.7}$$

where c represents the consumption for a representative farmer, ρ is a constant subjective rate of time preference.

Substitute (5B.2) and (5B.3) into (5B.7), so that the relevant constraint for the control problem can be expressed as

$$c(t) = B_3 k_2^{\alpha_4}(t) - \beta pd - I(t) \tag{5B.8}$$

for

$$B_3 = \beta p[\ 1 - C_0 m)\ ]\alpha_0 l^{\alpha_2} k_1^{\alpha_3}\,. \tag{5B.9}$$

Maximising (5B.8) subject to (5B.5) and (5B.6), with the equality constraint (5B.7), gives the following first order conditions

$$c(t)^{-\sigma} = \lambda(t) \tag{5B.10}$$

$$\lambda(t) = \varphi(t) \qquad \text{B.11)}$$

The state and costate variable (or $\varphi(t)$) satisfies the conditions

$$\dot{\varphi} = -\lambda(t)B_3\alpha_4 k_2{}^{\alpha_4 - 1} + \varphi(t)(\mu + n + \rho) \tag{5B.12}$$

$$\dot{k}_2(t) = \frac{\partial H}{\partial \varphi} = I(t) - (\mu + n)k_2(t) \tag{5B.13}$$

along with the initial condition as given in (5B.6) and the appropriate transversality condition.

The phase diagram in (c, k_2) space is constructed from the simultaneous differential equations for c and k_2, which are derived from the results above. Combining (5B.10) and (5B.11), and differentiating with respect to time gives the differential equation for consumption, or

$$\dot{c}(t) = \frac{1}{\sigma}\left[B_3\alpha_4 c(t)k_2(t)^{\alpha_4 - 1}\right] - \frac{1}{\sigma}c(t)(\mu + n + \rho)\,. \tag{5B.14}$$

The differential equation for physical capital *(k_2)* can be derived by substituting the value of *I(t)*, which is given in equation (5B.13) into equation (5B.8), so that

$$\dot{k}_2(t) = B_3 k_2^{\alpha_4} - \beta pd - (\mu + n)k_2(t) - c(t)\,. \tag{5B.15}$$

Next, derive the two demarcation curves or loci of points where $\dot{c}$=0 and $\dot{k}_2$ =0.

For $\dot{c}=0$*:* From (5B.13), the locus of points where $\dot{c}=0$ is graph of the equation

$$\left[B_3\alpha_4 k_2(t)^{\alpha_4-1}\right]-(\mu+n+\rho)=0 \tag{5B.16}$$

so that

$$k_2^{\;N}=\left[\frac{B_3\alpha_4}{\rho+\mu+n}\right]^{\frac{1}{1-\alpha_4}} \tag{5B.17}$$

gives the steady-state value of k_2^N (see Figure 5.3).

For $\dot{k}_2=0$*:* From equation (5B.15) we have

$$B_3 k_2(t)^{\alpha_4}-(\mu+n)k_2(t)-c(t)-\beta pd=0. \tag{5B.18}$$

Totally differentiating (5B.17) with respect to c and k_2, gives

$$\left.\frac{dc}{dk_2}\right|_{\dot{k}_2=0}=\alpha_4 B_3 k_2^{\;\alpha_4-1}-(\mu+n) \tag{5B.19}$$

and substituting B_3, as defined in (5B.9), into (5B.18) gives

$$\left.\frac{dc}{dk_2}\right|_{\dot{k}_2=0}=\overline{\beta}\overline{p}(1-\overset{+}{\overline{C_0}}\overline{m})\frac{\partial q}{\partial k_2}-(\mu+n). \tag{5B.20}$$

With Inada conditions, and as argued in the paper, $\left.\frac{dc}{dk_2}\right|_{\dot{k}_2=0}$ is positive and decreases when k_2 increases; $\left.\frac{dc}{dk_2}\right|_{\dot{k}_2=0}$ equals zero when k_2 increases to a value that makes $\beta p(1-C_0 m)\frac{\partial q}{\partial k_2}$ equal to $(\mu+n)$; and the value $\left.\frac{dc}{dk_2}\right|_{\dot{k}_2=0}$ is negative and decreases when k_2 increases further. Therefore, the shape of the $\dot{k}_2=0$ curve is concave as indicated in the Figure 5.3.

The variation of $\dot{c}$ respect to c in equation (5B.14) is given by

$$\frac{\partial\dot{c}}{\partial c}=\frac{1}{\sigma}\left[B_3\alpha_4 k_2^{\;\alpha_4-1}-(\rho+\mu+n)\right] \tag{5B.21}$$

and equations (5B.16) and (5B.22) imply that

$$\frac{\partial \dot{c}}{\partial c} > 0 \text{ if } k_2 < k_2^E \text{ and } \frac{\partial \dot{c}}{\partial c} < 0 \text{ if } k_2 > k_2^E . \tag{5B.22}$$

The variation of $\dot{k}_2$ respect to k_2 from equation (5B.17) is given by

$$\frac{\partial \dot{k}_2}{\partial k_2} = \alpha_4 B_3 k_2^{\alpha_4 - 1} - (\mu + n) \cdot \tag{5B.23}$$

It is noted that the sign of variation of $\dot{k}_2$ is the same sign as $\left.\frac{dc}{dk_2}\right|_{\dot{k}_2 = 0}$ in the equation (5B.20).

All motions and trajectories are as depicted in Figure 5.3. The steady-state is a saddlepoint.

When $\dot{c} = \dot{k}_2 = 0$, then the value physical capital k_2^N, is as indicated in (5B.17). Substituting that value into equation (5B.18), the equilibrium value for consumption is given as

$$c^N = \left(\frac{B_3 \alpha_4}{\rho + \mu + n}\right)^{\frac{1}{1-\alpha_4}} \left[\frac{\rho + (1 - \alpha_4)(\mu + n)}{\alpha_4}\right] - \beta p d \cdot \tag{5B.24}$$

Appendix 5C: THE COMPARISON OF STEADY STATE FOR PHYSICAL CAPITAL WITH AND WITHOUT THE INCENTIVE EFFECTS OF TRADE LIBERALISATION

Consider the value of the steady-state for physical capital in the growth model under trade liberalisation as given as equation (5.32)

$$k_2^* = \left\{ \frac{B_4 \alpha_4^{\,1 + \frac{\sigma(\alpha_1 + \alpha_2)}{z - \alpha_1 - \alpha_2}}}{(\mu + n + \rho)\left[(1 - \alpha_4)(\mu + n) + \rho\right]^{\frac{\overset{>1}{z - \alpha_1 - \alpha_2}}{\sigma(\alpha_1 + \alpha)_2}}} \right\}^{\frac{1}{(1-\gamma_4) + \frac{\sigma(\alpha_1 + \alpha_2)}{z - \alpha_1 - \alpha_2}}} . \tag{5C.1}$$

It follows that

$$k_2^* > \left\{ \frac{B_4 \alpha_4^{1+\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}}{\underbrace{(\mu + n + \rho)}_{(0,1)} (\mu + n + \rho)^{\frac{\overbrace{z-\alpha_1-\alpha_2}^{>1}}{\sigma(\alpha_1+\alpha)_2}}} \right\}^{\frac{1}{(1-\gamma_4)+\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}} \tag{5C.2}$$

and

$$k_2^* > \left\{ \frac{B_4 \alpha_4^{1+\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}}{\underbrace{(\mu + n + \rho)}_{<1}} \right\}^{\frac{1}{(1-\gamma_4)+\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}} \tag{5C.3}$$

It can be shown that

$$\frac{1}{1 - \gamma_4 + \frac{\sigma(\alpha_1 + \alpha_2)}{z - \alpha_1 - \alpha_2}} > \frac{1}{1 - \alpha_4} > 1 \quad . \tag{5C.4}$$

By substituting the value of γ_4 given in the 'institutional production function', we can rewrite (5C.4) as

$$\frac{z - \alpha_1 - \alpha_2}{z - \alpha_1 - \alpha_2 - z\alpha_4 + \sigma(\alpha_1 + \alpha_2)} > \frac{1}{1 - \alpha_4} \tag{5C.5}$$

The inequality (5C.5) is equivalent to

$$z - \alpha_1 - \alpha_2 - z\alpha_4 + \sigma(\alpha_1 + \alpha_2) < (1 - \alpha_4)(z - \alpha_1 - \alpha_2) \tag{5C.6}$$

or

$$\sigma(\alpha_1 + \alpha_2) < \alpha_4(\alpha_1 + \alpha_2) \tag{5C.7}$$

and

$$\sigma < \alpha_4 . \tag{5C.8}$$

Therefore, as discussed in the paper, the inequality (5C.4) is satisfied if the inverse of the intertemporal elasticity of substitution for consumption in the future is less than (or, as discussed in the paper, equal to) the share parameter for the capital input in the technical production function.

Although *not* strictly necessary for the result, with (5C.8) satisfied, the inequality (5C.3) can be rewritten as

$$k_2^{\bullet} > \left\{ \frac{B_4 \alpha_4^{1+\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}}{\underbrace{(\mu + n + \rho)}} \right\}^{\frac{1}{1-\alpha_4}} \tag{5C.9}$$

and since the value of B_4 in equation (5.22) of the paper is greater than the value of B_3 in equation (5.9), the inequality (5C.9) can be given as

$$k_2^{\bullet} > \left\{ \frac{B_4 \alpha_4}{\underbrace{(\mu + n + \rho)}_{k_2^N}} \right\}^{\frac{1}{1-\alpha_4}} \tag{5C.10}$$

The right hand side of the inequality is the steady-state value for physical capital in the growth model without the effects of trade liberalisation (see (5B.17)). Therefore, the inequality in (5B.10) means that under trade liberalisation, or with the presence of incentive effects, other things being equal, the value of the steady state for physical capital is greater.

Part Three

An empirical analysis of the effects of internal and external trade liberalisation on rice production in Vietnam

Chapter 6

RICE PRODUCTION IN VIETNAM

As a preliminary step for the empirical research that follows in Chapters 7 and 8, this chapter contains a general overview of the rice industry and an econometric analysis of the functional form for Vietnamese rice production. Section 6.1 describes the geography and climate of Vietnam, highlighting the major rice producing areas. It also includes some relevant data regarding rice production and the performance of the rice industry. Section 6.2, most importantly, estimates, with a view toward designating the relative importance of each input, the share parameters of labour, land, current inputs and capital in the rice production function. Section 6.3 concludes.

6.1 An overview of the rice production and theoretical application

Rice is the most significant industry in Vietnamese agriculture. In fact, it absolutely dominates agricultural and foodstuff production, and that role has become even more important during the process of economic reform. With reform, the proportion of rice in foodstuff production has increased from 80.8 per cent (in 1980) to 97.6 per cent (in 1996), and from 79.4 per cent (in 1980) to 85 per cent (in 1996) in terms of output (unhusked rice equivalent) and sown area respectively (GSO, various years). Rice production also absorbs the greatest percentage of the labour force in rural areas, where about 70 per cent of workers in the Vietnamese economy live and, on average, contributes 67 per cent of household income (World Bank, 1995).

In addition, rice production is a crucial source of nutrition for the population. In Vietnam, starch-products make up 90 per cent of daily nourishment and, of that, rice supplies 83.1 per cent of calorie intake in the rural regions and 77.6 per cent in the urban areas (Ministry of Agriculture and Food Processing Industry, MAFI, 1987 quoted by SDP,1995a).[1] Moreover, rice exports are an important source of export revenue, accounting for (approximately) 30 per cent of total export revenue (GSO, 1996; and Ministry of Trade (MIT), 1992 and 1995).

(a) Geography and climate

Vietnam is naturally suited for rice production, especially for so-called wet rice production. Located in a tropical area with high humidity, the weather is especially amenable and the land is fertile. With this, Vietnam is also blessed with an advantageous water system, with an extensive network of rivers, favourable topography and rain fall patterns (World Bank, 1996a). The two deltas, the Cuu Long River Delta (CRD) and the Red River Delta (RRD), which are the main areas for rice production,

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[1] Although, it is argued that in Asia, rice is becoming an inferior good (Ito, Peterson and Grant, 1989).

contain most of the population and are situated over one-thousand kilometres apart. Besides these two main deltas, the Trung Bo delta, although small and narrow, is also very productive and located in the centre of the country.

Although humid and tropical weather is predominant overall, there are still some differences between north and south. The monsoon influences the north with four different seasons, Spring (March to April), Summer (May to August), Autumn (September to October) and Winter (November to February), and the rainy season dominates the weather in the south with two seasons, the wet (June to November) and the dry season (December to May). The instability caused by flood and drought are the main problems and as such provide riskiness for agriculture producers in general and cultivation in particular. For example, for the Summer-Autumn crop of 1991 in the Red River Delta, the output of rice decreased by 1.4 million tons. In contrast, in the Summer-Autumn rice crop of 1993 in the Cuu Long River Delta output decreased by 1 million tons (Nguyen S Cuc, 1995a) both because of drought and the resulting problems with insects. In addition, storms and flooding resulted in 1 million tons less of rice output in both deltas in 1994, but, nevertheless, the total output of rice still reached 23.5 million tons (Nguyen S Cuc, 1995b and GSO,1996). In general, with the variable climate, flooding and insect problems are the main causes for up to 6-7 per cent of the reduction in rice output. However, the increasing use of irrigation systems partially offsets problems with weather and especially so for wet rice production. In Vietnam, the irrigation system maintains the water supply and guards against flooding for about 54 per cent of the cultivated area (Ministry of Water Resource, MWR, 1994 and World Bank, 1996), although, it must be remarked, this percentage is still much lower than in the other rice export economies such as Thailand (80 per cent, SDP, 1995a).

The Cuu Long River Delta with an area of 3.9 million hectares provides 2.8 million hectares for rice production, with a population of 12, 8 million (GSO, 1995a). This rice area was formed by the alluvial soil raised by the Cuu Long and Bassac rivers. In these areas, the high concentration of alluvial soil accounts for 1.164 million (very fertile) hectares of total land. In the wet season, flooding often threatens around 25 per cent of the sown area and induces poor crops (SDP, 1995a), but generally, favourable conditions in the Cuu Long River Delta allow for a triple crop of rice during the year; the Winter-Spring crop between March and May, the Summer-Autumn crop between August and September and the Winter crop from December to the following January.

The area of the Red River Delta is 1.7 million hectares, with a population of 11.5 million (GSO, 1995a). The population density is highest in Thai Binh province with about 1,100 persons/ km2 (GSO, 1996). The area of rice cultivation is about 600,000 hectares (GSO, 1996). Flooding often negatively influences about 800,000 hectares but, having said this, the irrigation system is much better than that in the CRD and consequently it maintains a stable water supply for about 85 per cent of the total area.[2] Occasional drought and insects, nevertheless, still badly affect the size of the crop. Overall, the conditions of the alluvial soil and the weather are less favourable than that in the Cuu Long River Delta, since about 88 per cent of the total rice area cultivated can only provide for double (not triple) harvests: the Winter-Spring crop between May and June, and the Winter crop between November and December (SDP,1995a).

[2] Report by the MWR, 1994: The 'Da River' electronic hydraulics project provides a positive externality to the general hydraulic conditions in the Red River Delta. The dam from this project induces a lower level of maximum flooding in Hanoi from 14.6 m to 13 m, and the velocity of flooding in the high area of the Red River, from 38,000 m/minute to 23,000 m/minute.

Besides two main deltas, the Trung Bo delta, with an area for cultivation of only (approximately) 497,000 hectares (GSO), satisfies only the demand for rice within its own local area. Generally, conditions of the soil and the weather are much less favourable than in the CRD and the RRD as well.

(b) Rice production and the performance of the rice industry

Although, rice production has experienced fluctuations from year to year (see Table 6.1), it is possible to designate three significant periods in rice output: 1976-80, 1981-87 and 1988-1994. As the discussed earlier, in terms of Figure 2.2 (Chapter 2), the general trend of the growth of food grain and rice has shown a decrease in 1976-80, a marked increase in 1981-87, and an extreme boom in yields since 1988 until the present.

In the period 1976-80, the decrease in the output of rice production occurred simultaneously with the campaign of collectivisation in the north and south, as well as throughout the whole of Vietnam. The output of unhusked rice never reached more than 12 million tons per annum and that was much less than the ambitious target of 21 million tons of food grain per annum set by the Fourth Party Congress (Congress of Communist Party IV, CCP, 1976). At that time, and although Vietnam is (to say the least) an agricultural economy, the agricultural sector could not provide enough output to feed its own population. The serious shortage of foodstuffs and severe fall in the standard of living caused Vietnam to be a heavy importer of foodstuffs from other supporting socialist countries or the CMEA (see Tables 6.1 and 6.2).

Table 6.1 **Output, cultivated area and yield of rice production of Vietnam (1976-94)**

	VIETNAM			NORTH			SOUTH		
	Unhusked rice output	Rice cultivated area	Yield of rice	Unhusked rice output	Rice cultivated area	Yield of rice	Unhusked rice output	Rice cultivated area	Yield of rice
	(thous tons)	*(thous hectare)*	*(tons/hectare)*	*(thous tons)*	*(thous hectare)*	*(tons/hectare)*	*(thous tons)*	*(thous hectare)*	*(tons/hectare)*
1976	11821.7	5297.3	2.2	5457.7	2383.6	2.3	6364.0	2909.6	2.2
1977	10533.3	5468.7	1.9	4645.9	2326.9	2.0	5887.4	3034.3	1.9
1978	9764.4	5462.5	1.8	4749.6	2425.9	2.0	5014.8	3010.2	1.7
1979	11310.6	5485.2	2.1	4878.7	2439.7	2.0	6431.9	3011.4	2.1
1980	11578.9	5600.2	2.1	4371.4	2306.5	1.9	7207.5	3236.2	2.2
1981	12415.2	5651.9	2.2	5401.1	2480.7	2.2	7014.1	3171.2	2.2
1982	14390.1	5711.4	2.5	6170.5	2495.2	2.5	8219.6	3216.2	2.6
1983	14743.3	5611.0	2.6	6174.1	2476.5	2.5	8569.2	3134.5	2.7
1984	15505.6	5675.0	2.7	6200.0	2470.6	2.5	9305.6	3204.4	2.9
1985	15874.3	5703.9	2.8	6292.0	2501.5	2.5	9582.3	3202.4	3.0
1986	16002.9	5688.6	2.8	6262.8	2441.9	2.6	9740.1	3246.7	3.0
1987	15102.6	5588.5	2.7	6075.2	2450.4	2.5	9027.4	3138.1	2.9
1988	17000.0	5726.4	3.0	6708.7	2464.8	2.7	10291.3	3261.6	3.2
1989	18996.3	5895.8	3.2	7275.4	2481.2	2.9	11720.9	3414.6	3.4
1990	19225.1	6027.7	3.2	6962.4	2483.5	2.8	12262.7	3544.2	3.5
1991	19621.9	6032.7	3.3	6257.5	2509.5	2.5	13364.4	3793.2	3.5
1992	21590.3	6475.4	3.3	7885.1	2522.1	3.1	13705.2	3953.3	3.5
1993	22836.6	6386.8	3.6	8973.3	2502.8	3.6	13863.3	3884	3.6
1994	23528.3	6559.4	3.6	9100.0	2519.4	3.6	14428.3	4040	3.6

Sources: *The Statistics Department of Agriculture, Forestry and Fishing (SDAFF)- General Statistics Office (GSO)*

In the period of de-collectivisation and a tightly controlled markets (1980-1987), the output and yield increased slowly until 1987, or from about 11 million tons and 2.1 tons per hectare (1980) to about 15 million tons and 2.7 tons per hectare (1987) respectively (Table 6.1). Vietnam overcame its food shortage crisis and had more balance in terms of its importation of foodstuffs (Table 6.2). However, the prospect of exporting rice was clearly not available yet.

***Table 6.2* Import and export foodstuff in Vietnam (1976-94)** *(thousand tons)*

Year	IMPORT				RICE EXPORT	NET EXPORT
	Rice	Wheat	Flour	Other		
1976	147.60	249.00	247.70	88.90		-733.20
1977	196.50	463.00	507.40	95.90		-1262.80
1978	34.45	738.3.0	50.10	104.80		-927.65
1979	117.41	633.00	634.10	20.70		-1405.21
1980	201.37	343.30	442.70	4.83		-992.20
1981	56.17	223.50	300.30			-579.97
1982	184.79	63.70	86.67			-335.16
1983	46.30		42.55			-88.85
1984	322.0	15.38	21.60			-358.98
1985	336.08	83.47	27.68			-447.23
1986	482.50	27.60	35.20	3.00		-548.30
1987	332.60	56.00	107.00			-495.60
1988	199.50	0.00	250.70	6.77		-456.97
1989	55.10	25.00	106.50	6.00	1372.60	-1180.00
1990		27.50	141.20	2.00	1624.40	1453.70
1991	6.00	56.00	197.00		1273.00	1014.00
1992		29.78	252.24		2191.00	1909.00
1993		14.52	250.87		1908.00	1642.60
1994		49.00	250.00		2360.00	2061.00

Source: *The General Statistics Office, the Rice Trader and the State Department of Price (1995b).*

As mentioned, the boom in rice output and yield happened in the period characterised by the strongest push for liberalisation or from 1988-89 until the present. In 1989, for the first time, Vietnam reached the threshold of 21 million tons of food grain (in terms of rice equivalent) and about 19 million tons of rice output (GSO, 1990 and Table 6.1). It was also the first time in fifty years that Vietnam became a rice exporter. Indeed, the export volume of rice from Vietnam increased rapidly over time and Vietnam soon became the third largest exporter of rice in the world (see Table 6.2).

Despite the constant problem of low and inconsistent rice quality, high quality rice exports (the proportion of broken rice being 5-10 per cent) in the total volume of exports have increased from 40 per cent in 1991 to 64.44 per cent in 1993 (according to the Ministry of Trade, MIT)[3]. However, the low and inconsistent quality of exported rice is still the most serious problem for Vietnam in terms of participation in world markets (Luu V Dat, 1993 and Vo T Xuan, 1995a).

Corresponding to the high rates of growth of rice output, supporting inputs have also improved and have grown rapidly. In fact, while rice area sown has decreased (Nguyen T Khiem, 1995) under the pressure of urbanisation and diversified crops in agriculture, the total amount of cultivated rice has increased rapidly over time (see Table 6.1) due to the more intensive exploitation of land and the use of high-yield rice crops. In addition, a decrease in the large amount of the wasteland (with its impoverished soil)

[3] Participation in the foreign rice trade industry includes three kinds of partners: central government companies, local government companies and private organisations. At the central state level, there are three corporations for trading rice: Vinafood I in the north, Vinafood II in the south and Foodstuff Corporation III in the centre. Foodstuff State Corporation's branch in every province manages the network of foodstuff shops and has the rights for foreign trade. As such private companies do not have the rights to trade rice, but illegal private activities on the China-Vietnam border possibly amount to of 0.4 to 0.6 million tons of trade (Rice Trader, 1995). Because of the low quality requirement, the higher price, and the lower of transportation costs and flexible terms of trade, the amount of rice export going to China-legally (or illegally) has increased strongly. The amount of exports to China has increased from 24 per cent of total export volume (2.36 million ton) in 1994 to 53 percent of total export volume (1.78 million ton) in the first six months of 1995 (Rice Trader, 1995).

has improved the rice fields generally. Rice output has also been enhanced by crop rotation, new technology, irrigational systems, higher quality and new kinds of seeds, and the more intensive use of labour and current inputs. Irrigated area, for example, has risen from 1.2 million hectares in 1976 to 1.88 million hectares in 1994 (MRW, 1994) and the amount of fertiliser use in terms of nitrogen, phosphates and potassium (NPK) in 1994 was 3.5 times that of 1976 (GSO).[4]

6.2 The econometric estimation of the share parameters of inputs in the rice production function

This section applies the form of institutional production function (see Chapter 3 above) to estimate the share parameter of inputs in the rice production function.[5] Following the static institutional production function from Chapter 3, it is argued that trade liberalisation in Vietnam can affect the level of rice production. In what follows the share parameters of inputs (γ_1, γ_2 , γ_3 and γ_4) are assumed to be constant during the process of trade liberalisation[6], with estimated share parameters in one given year being used for all years in the process of liberalisation.

Here, the estimation is carried out for the year 1993 because the National

[4]Evidently, the high growth in supporting factors of production has contributed to the rapid development in rice production. However, all of this is qualitative in its account. The empirical research regarding the effects of internal and external trade liberalisation requires a precise quantitative evaluation. As mentioned, Section 6.2 provides an estimation of the share parameters of inputs for labour, land, current input and capital in the rice production function.

[5]The original assumption (in the theoretical framework in Chapter 3 above) about the form of 'technical' production function as Cobb-Douglas with constant returns to scale is also relevant for rice production in Vietnam. because the technology level for Vietnamese agriculture is the similar to that in other agrarian and Less Developed Countries (LDC's). In other words, the production function for agriculture or rice production in Vietnam is Cobb-Douglas and with constant returns to scale just as in the other LDC's (according to empirical research for 22 LDC's by Hayami and Ruttan (1985), and for China by Tang, (1980, p.28).

[6] see Section 4.4, Chapter 4.

Investigation of Rural Regions, NIRR (by SDAFF, GSO,1995b) provides the best data for regression in that year. Further, in 1993, the full process of liberalisation had already taken place, so that the estimated results strongly reflect this feature in the form of the institutional production function for rice.

The economic specification in equation (3.20) and all assumptions and specifications contained in Chapter 3 above are applied to the empirical work here. The econometric specification is generated by taking the logarithm of equation (3.20) so that

$$lq = la + +\gamma_1\, ln + \gamma_2\, llan + \gamma_3\, lk_1 + \gamma_4\, lk_2 \tag{6.1}$$

where lq,, la, ln, $llan$, lk_1 and lk_2 are the log-forms of output, total factor productivity, labour, sown area, current inputs and the capital input respectively.

The estimation for rice production is carried out using cross-sectional data from 53 provinces and cities in 1993 (see Table 6.3). The Data Appendix below (see Section DA.1 in particular) provides detailed explanations of all the economic terms used, such as current input, physical capital, and so on, the formulas for determining them, as well as data sources and adjustment for the data set presented in Table 6.3.

The estimated results for share parameter of inputs (see Table 6.4) are quite significant for the constant term, land, current input and capital. Only the result for labour is not significant. The F-test for all regressions indicates high significance, so in general the outcome of the regression is acceptable. The sum of all coefficients for share parameters of inputs is about 1.1. However, the Wald-test for the restriction of constant returns to scale indicates that we could not in fact reject the hypothesis of constant returns to scale for the rice production function (at 5 per cent significance).

Table 6.3 **The cross-sectional data set used for econometric estimation**

	Province	Output (thous tons)	Labour (thous pers)	Land (thous ha)	Current input (thous tons)	Capital (ten thous horsepower)
1	Ha Giang	134.20	158.60	24.38	15.40	4.84
2	Tuyen Quang	166.10	172.69	26.28	24.72	4.67
3	Cao Bang	156.80	187.92	27.30	21.88	8.0
4	Lang Son	160.90	185.40	35.24	31.34	7.98
5	Lai Chau	151.40	141.71	44.85	23.61	4.20
6	Lao Cai	128.60	146.98	24.61	18.53	3.55
7	Yen Bai	155.80	114.52	23.83	22.76	3.29
8	Bac Thai	269.00	276.08	56.63	47.41	7.30
9	Son La	171.20	215.07	50.08	29.63	5.99
10	Hoa Binh	163.50	182.39	41.62	25.64	4.56
11	Quang Ninh	152.10	99.30	29.51	19.52	3.30
12	Vinh Phu	506.00	641.40	96.07	99.53	8.57
13	Ha Bac	640.10	782.70	118.55	118.54	9.03
14	Ha Noi	206.30	245.85	37.17	39.00	4.45
15	Hai Phong	440.00	316.41	50.65	63.48	1.54
16	Ha Tay	682.40	691.62	95.44	108.48	4.90
17	Hai Hung	1079.60	783.81	131.06	138.74	4.18
18	Thai Binh	968.90	573.46	88.99	94.03	3.46
19	Nam ha	792.60	677.25	128.72	138.87	2.55
20	Ninh Binh	269.10	168.46	46.25	42.28	3.21
21	Thanh Hoa	924.80	756.44	148.62	147.74	14.26
22	Nghe An	644.50	677.22	110.20	108.10	15.82
23	Ha Tinh	349.80	309.33	68.12	59.93	8.57
24	Quang Binh	148.50	188.89	33.21	30.04	4.67
25	Quang Tri	105.30	100.26	24.06	21.39	4.17
26	Thua Thien Hue	135.00	161.84	21.57	29.23	2.85
27	Quang Nam -DN	463.80	390.72	64.49	71.01	9.07
28	Quang Ngai	303.10	298.89	41.40	54.21	7.67

Table 6.3 **The cross-sectional data set used for econometric estimation *(continues)***

No	Province	Output *(thous tons)*	Labour *(thous pers)*	Land *(thous ha)*	Current input *(thous tons)*	Capital *(ten thous horsepower)*
29	Binh Dinh	444.30	286.83	53.28	63.56	8.58
30	Phu Yen	279.70	166.26	33.44	33.61	6.52
31	Khanh Hoa	180.60	130.07	23.54	21.74	5.33
32	Ninh Thuan	127.90	82.98	15.66	17.76	6.97
33	Binh Thuan	234.90	105.38	53.85	29.06	11.60
34	Gia Lai	166.10	93.43	65.16	26.98	10.54
35	Kon Tum	73.90	42.47	19.29	9.71	2.23
36	Dac Lac	286.10	118.15	65.08	32.56	6.74
37	Lam Dong	138.30	110.63	22.35	16.10	10.34
38	Hochiminh City	248.30	188.40	57.11	42.02	6.45
39	Song Be	132.10	122.06	32.57	23.04	18.67
40	Tay Ninh	390.50	147.42	107.36	44.02	16.02
41	Dong Nai	439.40	180.21	56.90	27.79	8.69
42	Baria-Vung Tau	117.40	63.05	16.63	8.03	9.74
43	Long An	1003.00	442.33	178.89	101.00	25.44
44	Dong Thap	1591.00	539.54	183.35	115.69	35.83
45	An Giang	1898.80	609.90	215.52	134.02	39.38
46	Tien Giang	1190.90	467.23	99.98	93.54	13.97
47	Ben Tre	333.60	327.01	59.52	55.49	7.6
48	Vinh Long	819.30	340.57	74.13	59.96	12.83
49	Tra Vinh	651.90	287.18	96.62	60.52	7.79
50	Can Tho	1481.50	519.81	150.36	110.75	25.88
51	Soc Trang	1002.30	356.18	182.98	98.02	18.59
52	Kien Giang	1223.90	448.11	221.99	109.60	22.25
53	Minh Hai	1093.10	502.84	264.21	131.03	15.86

Source: *From Tables DA.1 through DA.3, see Section DA.1 (Data Appendix) for data sources and adjustments*

The other diagnostic tests also show that there are no important problems such as heteroscedasticity,[7] nor is there a problem in the form of the function,[8] by both *F* test and CUSUM test[9]. The *R* Bar squared is high in this case compared with the normal cross-section estimation (89 per cent).

***Table 6.4* The share parameters of inputs in the rice production function**

(53 observations in 1993)

The dependent variable is the log of the output of rice (thousand tons)

Factor input	Coefficients	p value
Constant term	a= 0.5	0.02
Labour	n= 0.2	0.29
Land	lan= 0.4	0.00
Current inputs	k_1= 0.4	0.09
Capital	k_2= 0.1	0.02
	R Bar Squared = 0.89	F(4,48): 116.9 (0.000)

The estimated results indicate the very important role of sown land and current inputs in the rice production function (the coefficient is 0.4), while the share of labour is only 0.2 (but *p* for that coefficient is high at 0.29). The fixed amount of land limits the growth of output, so the only alternative for any increase in the capacity of land to increase output and yield comes (at least for Vietnam for the moment) from capital improvements, and particularly so in the irrigation system. According to the World Bank (1995b), irrigation in Vietnam can add substantially to land value: the difference between zero and 100 per cent irrigation amounts to 645 kg/ha in rice. Indeed, this

7 By testing square residuals on squares fitted value.
8 Ramsey Reset test by using squares of fitted value.
9 The CUSUM test at 5 per cent significance shows that only one small part of the tested line is slightly out of the critical area.

result regarding the importance of the role of current inputs is fully consistent with the conclusions drawn in the research on the rice production conducted by the United Nations Development Program, UNDP and the Food and Agriculture Organisation, FAO (1989). There, chemical fertiliser also weighs as the most important factor in current inputs and in fact the expenditure on fertiliser is the major cost component faced by rice farmers, at about 65 per cent of total variable cost (Nguyen T Khiem, 1995).[10]

As mentioned above, the estimated results reflect the share parameter of inputs in the institutional production function (γ_1, γ_2 , γ_3 and γ_4), but the share parameters of inputs in the 'technical' production function (or α_1, α_2 , α_3 and α_4) are still unknown. However, we can derive α_1, α_2 , α_3 and α_4 from these estimated results and the coefficient z, according to equations (3.22) through (3.25). An alternative approach to determine z and the 'technical' share parameter of inputs (α_1, α_2 , α_3 and α_4) is presented in Appendix 7A (Chapter 7). This appendix shows that the technical share parameter of inputs for Vietnam are 0.4, 0.3, 0.2 and 0.1 for labour, land, current input and capital respectively. The 'technical' share parameters of inputs in the rice production function for the Vietnamese case shows constant returns to scale which again is appropriate to the assumptions used in Chapter 3. Note, that the 'technical' share parameters of inputs in the rice production function for Vietnam do not differ much from those for other LDCs where the 'technical' share parameters of inputs are 0.5, 0.25, 0.1 and 0.15 in China (Tang, 1980, p.28) and 0.53, 0.1, 0.21 and 0.16 in twenty-two LDCs (Hayami-Ruttan, 1985, Chapter 6) for labour, land, current inputs and capital

[10]Needless to say, there will be diminishing marginal returns to chemical fertiliser use on rice output (UNDP-FAO, 1989). Besides, techniques for minimising chemical fertiliser and pesticides, while stabilising grain yield, are also needed to reduce the farmer's production costs and environment pollution (Vo T Xuan, 1995b). Improvement, instead, in technology and capital investment (e.g., irrigation) is a crucial requirement for further increases in output in the long run.

respectively.

6.3 Concluding remarks

Since 1989, Vietnam has grown to be the third largest rice exporter in the world. This chapter provides the first step in the quantitative analysis of the rice production function by estimating the share parameters of inputs in the rice production function using cross-sectional data in 1993 for 53 provinces and cities. The estimated results indicate that the share parameters of labour, land, current inputs and capital for rice production are 0.2, 0.4, 0.4 and 0.1 respectively. On this basis, the following two chapters provide an empirical examination of how trade liberalisation affects rice output, first, as a static exercise (Chapter 7), then in terms of the dynamics of the growth in rice output (Chapter 8).

Chapter 7

AN EMPIRICAL ANALYSIS OF THE EFFECTS OF TRADE LIBERALISATION ON RICE PRODUCTION IN VIETNAM FROM 1976 TO 1994

Following the theoretical analysis in Chapters 3 and 4, and based on the estimated results for the share parameters in the rice production function in Section 6.2, this chapter directly and empirically examines the comparative effects of the different stages of liberalisation as an explanation for the rapid growth of the rice industry in Vietnam. The institutional production function derived in the previous chapter is used to separate the growth in rice output into a component due to the growth of factor inputs or supplies and another component due to the growth of total factor productivity.

This chapter is organised around two sections. Section 7.1 subtracts the growth of factor inputs from the total growth of rice output to obtain an estimate of the growth of total factor productivity. Section 7.2 computes directly that part of the growth of total factor productivity which can be attributed to liberalisation, allowing us to decompose total factor productivity growth into two components: one that results from the effects of trade liberalisation only, and one that is due to a host of other items or 'unexplained residuals'. Section 7.3 concludes and Appendix 7A provides the technical details regarding the calculation of the effort-disutility coefficient (z) and 'technical' share parameters for inputs. Detailed data sources and adjustments for this chapter are documented in Data Appendix below.

7.1 The growth of total factor productivity in the transitional periods of trade liberalisation

Based on the static model of Chapter 3, the estimated results in Section 6.2 (Chapter 6), and the actual growth rate of factor inputs, this section computes an index for the growth rate (g) of total factor productivity (A) in the process of trade liberalisation in Vietnam from 1980 to 1994.[1] To do so, begin with equation (3.20), or the institutional production function, so that the growth rate of total productivity is determined as

$$\frac{\dot{A}}{A}=\frac{\dot{Q}}{Q}-\gamma_1\frac{\dot{N}}{N}-\gamma_2\frac{\dot{L}}{L}-\gamma_3\frac{\dot{K}_1}{K_1}-\gamma_4\frac{\dot{K}_2}{K_2} \tag{7.1}$$

[1]in this regard it is useful to consider not only the whole of Vietnam but also the north and the south separately, due to the significant differences between the two areas. The differences in natural endowments between the north (represented by the Red River Delta) and the south (represented by the Cuu Long River Delta) were discussed in Section 6.1 (Chapter 6). The differences in economic structure and the processes of liberalisation between the two regions also were described in Section 2.2, Chapter 2 above. In brief, they are: (a) a peasant middle class in the south forms a strong presence in rural society and they are very experienced at operating within a market economy, and as such they are very reluctant to follow unreasonable commands from the State; (b) the south had more advanced technology and more developed markets for agricultural commodities, both of which had been established before unification; (c) the collective regime regulated more strongly in the north than in the south, i.e., the 'low advanced' and 'advanced cooperative' were dominant in the north, the 'production collective' was popular in the south; and (d) it is likely that the economic reforms in the south happened earlier and with more vigour than in the north.

and define *the cumulative rate of growth* of output and factor inputs at any time t relative to their levels at some specified initial time by

$$\frac{\dot{X}}{X} = \frac{X_t - X_0}{X_0} \tag{7.2}$$

where X_t and X_0 respectively define output and factor inputs at time t and at some initial (base) time period. The constructed index for the growth rate in this case is not the usual one based on a year-to-year or annual comparison. This enables us to focus on the overall changes *between* the various stages of trade liberalisation; e.g., the change in rice output in the period of output-contracts and the opening up of markets compared to rice output in the (base period) communal system.[2] The resulting index is thus constructed as a cumulative measure of all the relevant growth rates relative to a single base period and slows clearly the effects of movements from one period of trade liberalisation to another. Nevertheless, as a means of comparison, the average annual growth rates for output and various inputs across different transitional periods are also calculated. Here we use the fitted values of exponential growth rates as a basis for the measurement.

Given our discussion of the process of economic liberalisation in Vietnam (see Section 2.2, Chapter 2), let the initial situation (or the starting point) in the agricultural industry be defined by the communal system (1976-80). The process of trade liberalisation in Vietnam has then experienced two periods: the period of de-collectivisation with controlled markets (from 1981-87); and the period of the opening

[2] Indeed, this is exactly the type of index occasionally used in official Vietnamese statistics (e.g., GSO). With the limited number of observations, and the resulting inability to accurately fit a proper exponential (trend) function, a year-to-year comparison can in fact be misleading. Given dramatic changes from one year to the next (say as a result of a bad weather shock in one year), the calculated annual growth rate in the following year may read as an extremely high positive value even though the clear trend within the period (across all years in the given trade regime) is negative. Comparisons to a base period and the construction (as we will see) of a cumulative index help avoid this problem.

up or freeing of markets (1988-until now). Following equations (7.1) and (7.2), it is possible to compute an index of the cumulative growth rates of total factor productivity for the whole country, the north and the south in every year from 1980 to 1994.

The relevant time series data for rice output, labour, land, current inputs and capital for Vietnam, the north and the south in 1976-94 are presented in the Tables DA.4 through DA.9 (Data Appendix) and summarised in Table 7.1. The sources, adjustments and derivations of these data are documented in Data Appendix (Sections DA.2 and DA.3). With the initial situation immediately prior to the process of liberalisation being the period of the communal system, we can assume that the arithmetic average for the years 1976-80 constitutes the initial value (X_0) for each of output, labour, land, current input and capital. The cumulative growth of output and factor inputs for Vietnam, the north and the south, can be obtained (see Tables 7.2, 7.3 and 7.4) from equation (7.2) and the figures contained in Table 7.1. Substituting the values of the growth of output and factor inputs, and the estimated results of share parameters of inputs (see Section 6.2), into (7.1), we then get the cumulative growth of total factor productivity in Vietnam, the north and the south (see Tables 7.2, 7.3 and 7.4 respectively).

Quite clearly, total factor productivity has increased in direct correspondence to the process and progress of trade liberalisation and its growth is the most important component of the growth of rice output in the years 1980 to 1994 (see Tables 7.2 to 7.4 and Figure 7.1). Moreover, the growth rate of total factor productivity in the south is greater than that in the north and makes up the largest part of the growth of total factor productivity for the whole of the country.

Table 7.1 Output and inputs for rice production for Vietnam as a whole, the north and the south separately, 1976-94

Year	VIET NAM					THE NORTH					THE SOUTH				
	Rice output	Labour	Land	Current input	Capital	Rice output	Labour	Land	Current input	Capital	Rice output	Labour	Land	Current input	Capital
	(thous tons)	*(thous man day*	*(thous ha)*	*(thous tons)*	*(ten thous horsepower)*	*(thous tons)*	*(thous man day*	*(thous ha)*	*(thous tons)*	*(ten thous horsepower)*	*(thous tons)*	*(thous man day*	*(thous ha)*	*(thous tons)*	*(ten thous horsepower*
1976	11827.2	764.1	4710.0	2137.6	236.7	5457.7	584.9	1672.0	1141.3	144.6	6364.0	179.2	3038.0	996.4	92.1
1977	10597.1	764.2	4709.8	2129.6	243.8	4645.9	571.0	1671.8	1098.5	146.0	5887.4	193.2	3038.0	1031.1	97.9
1978	9789.9	782.1	4664.0	2186.7	237.9	4749.6	595.3	1666.5	1104.9	143.3	5014.8	186.8	2997.5	1081.8	94.6
1979	11362.9	786.0	4618.1	2127.7	245.2	4878.7	598.7	1661.1	1065.4	144.9	6431.9	187.3	2957.0	1062.3	100.4
1980	11647.4	768.6	4572.3	2026.4	263.7	4371.4	566.0	1655.8	980.4	153.2	7207.5	202.6	2916.4	1046.0	110.5
1981	12415.2	803.8	4526.4	2126.3	281.2	5401.1	608.8	1650.6	1035.2	148.6	7014.1	195.0	2875.8	1091.2	132.5
1982	14390.2	810.1	4480.5	2203.5	274.7	6170.5	612.3	1645.3	1080.4	146.9	8219.6	197.8	2835.2	1123.1	127.8
1983	14743.3	800.5	4434.6	2336.0	273.2	6174.1	607.7	1640.0	1148.1	148.2	8569.2	192.8	2794.6	1187.9	124.9
1984	15505.6	803.4	4388.8	2365.8	280.8	6200.0	606.3	1634.8	1162.9	151.3	9305.6	197.1	2753.9	1202.9	129.6
1985	15874.8	810.8	4296.5	2425.4	287.7	6292.0	613.9	1629.6	1192.9	153.8	9582.3	196.9	2666.9	1232.5	133.8
1986	16002.9	798.9	4250.0	2556.9	314.2	6262.8	599.2	1651.3	1242.3	166.2	9740.1	199.7	2598.7	1314.6	148.0
1987	15102.6	794.3	4242.6	2517.2	292.1	6075.2	601.3	1638.6	1230.7	159.3	9027.4	193.0	2604.0	1286.5	132.8
1988	17000.0	805.5	4108.9	2693.2	298.6	6708.7	604.9	1633.4	1286.7	164.6	10291.3	200.6	2490.9	1406.5	134.0
1989	18996.3	818.9	4108.0	2766.3	299.1	7275.4	608.9	1628.1	1330.3	157.1	11720.9	210.0	2490.0	1436.0	142.0
1990	19225.2	827.4	4108.0	2844.4	296.5	6962.4	609.5	1618.0	1382.1	158.4	12262.7	218.0	2490.0	1462.3	138.1
1991	19621.9	832.5	4101.0	2962.6	350.7	6257.5	615.8	1618.0	1391.6	173.9	13364.4	216.7	2531.0	1571.0	176.8
1992	21590.3	862.1	4100.0	3254.3	418.1	7885.1	618.9	1570.0	1551.6	198.2	13705.2	243.1	2517.0	1702.7	219.9
1993	22836.6	853.1	4038.6	3404.4	514.8	8973.3	614.2	1583.0	1609.3	227.6	13863.3	238.9	2455.6	1795.1	287.2
1994	23528.3	866.7	4038.6	3790.4	562.2	9100.0	618.3	1583.0	1877.3	248.6	14428.3	248.5	2455.6	1913.1	313.6
Annual growth rate (%)	4.7	0.6	-1.0	3.1	3.8	3.3	0.3	-0.3	2.7	2.3	5.6	1.4	-1.3	3.5	5.5

Source: *See Section DA.2 (Data Appendix) for data sources and adjustments*

Note: *Average annual growth rate is measured as the fitted value of the exponential growth rate*

Table 7.2 **The growth for total factor productivity in the transitional periods of trade liberalisation in Vietnam, 1976-94** *(per cent)*

Year	The cumulative growth of the factor: (*the figure at 1976-80 as 100*)						Percentage of contribution of (g_A) in growth rate of output
	Output	Labour	Land	Current input	Capital	Total factor productivity	
	(g_Q)	(g_N)	(g_L)	$(g_{K(1)})$	$(g_{K(2)})$	(g_A)	$(g_A)/(g_Q)$
1976-80	0.0	0.0	0.0	0.0	0.0	0.0	
1981	12.4	4.0	-2.8	0.2	14.5	11.2	90.0
1982	30.3	4.8	-3.7	3.9	11.9	28.1	92.8
1983	33.5	3.6	-4.7	10.1	11.3	29.5	88.1
1984	40.4	3.9	-5.7	11.5	14.4	35.8	88.8
1985	43.7	4.9	-7.7	14.3	17.2	38.4	87.8
1986	44.9	3.4	-8.7	20.5	28.0	36.7	81.7
1987	36.7	2.8	-8.9	18.6	19.0	30.4	82.7
1988	53.9	4.2	-11.7	26.9	21.6	44.8	83.1
1989	72.0	5.9	-11.7	30.4	21.8	61.2	85.0
1990	74.1	7.0	-11.7	34.1	20.8	61.7	83.2
1991	77.7	7.7	-11.9	39.6	42.9	60.7	78.2
1992	95.5	11.5	-11.9	53.4	70.3	69.6	72.8
1993	106.8	10.4	-13.2	60.5	109.7	74.8	70.1
1994	113.0	12.1	-13.2	78.7	129.0	71.5	63.3
Annual growth rate (per cent)							
	Output	Labour	Land	Current input	Capital	Total factor productivity	
1981-87	4.6	0.2	-1.3	2.9	2.3	3.8	
1988-94	6.1	1.3	-0.5	5.6	10.6	3.6	

Note: *Annual growth rate is measured as the fitted value of the exponential growth rate*

Table 7.3 **The growth for total factor productivity in the transitional periods of trade liberalisation in the north, 1976-94** *(per cent)*

Year	The cumulative growth of the factor: (*the figure at 1976-80 as 100*)						Percentage of contribution of (g_A) in growth rate of output
	Output	Labour	Land	Current input	Capital	Total factor productivity	
	(g_Q)	(g_N)	(g_L)	$(g_{K(1)})$	$(g_{K(2)})$	(g_A)	$(g_A)/(g_Q)$
1976-80	0.0	0.0	0.0	0.0	0.0	0.0	
1981	12.0	4.4	-0.9	-4.0	1.5	12.0	100.0
1982	28.0	5.0	-1.2	0.2	0.3	27.4	97.7
1983	28.1	4.2	-1.5	6.5	1.2	25.1	89.5
1984	28.6	4.0	-1.8	7.9	3.3	25.1	87.6
1985	30.5	5.3	-2.1	10.6	5.1	25.6	83.8
1986	29.9	2.7	-0.8	15.2	13.5	22.3	74.4
1987	26.0	3.1	-1.6	14.2	8.8	19.5	74.9
1988	39.2	3.7	-1.9	19.3	12.4	30.2	77.1
1989	50.9	4.4	-2.2	23.4	7.3	40.8	80.2
1990	44.4	4.5	-2.8	28.2	8.2	32.6	73.3
1991	29.8	5.6	-2.8	29.1	18.8	16.3	54.7
1992	63.6	6.1	-5.7	43.9	35.4	43.5	68.5
1993	86.1	5.3	-4.9	49.3	55.5	61.8	71.7
1994	88.8	6.0	-4.9	74.1	69.8	52.9	59.6
Annual growth rate (per cent)							
	Output	Labour	Land	Current input	Capital	Total factor productivity	
1981-87	2.9	0.2	-0.2	2.6	1.6	2.0	
1988-94	5.4	0.4	-0.6	5.6	6.8	3.3	

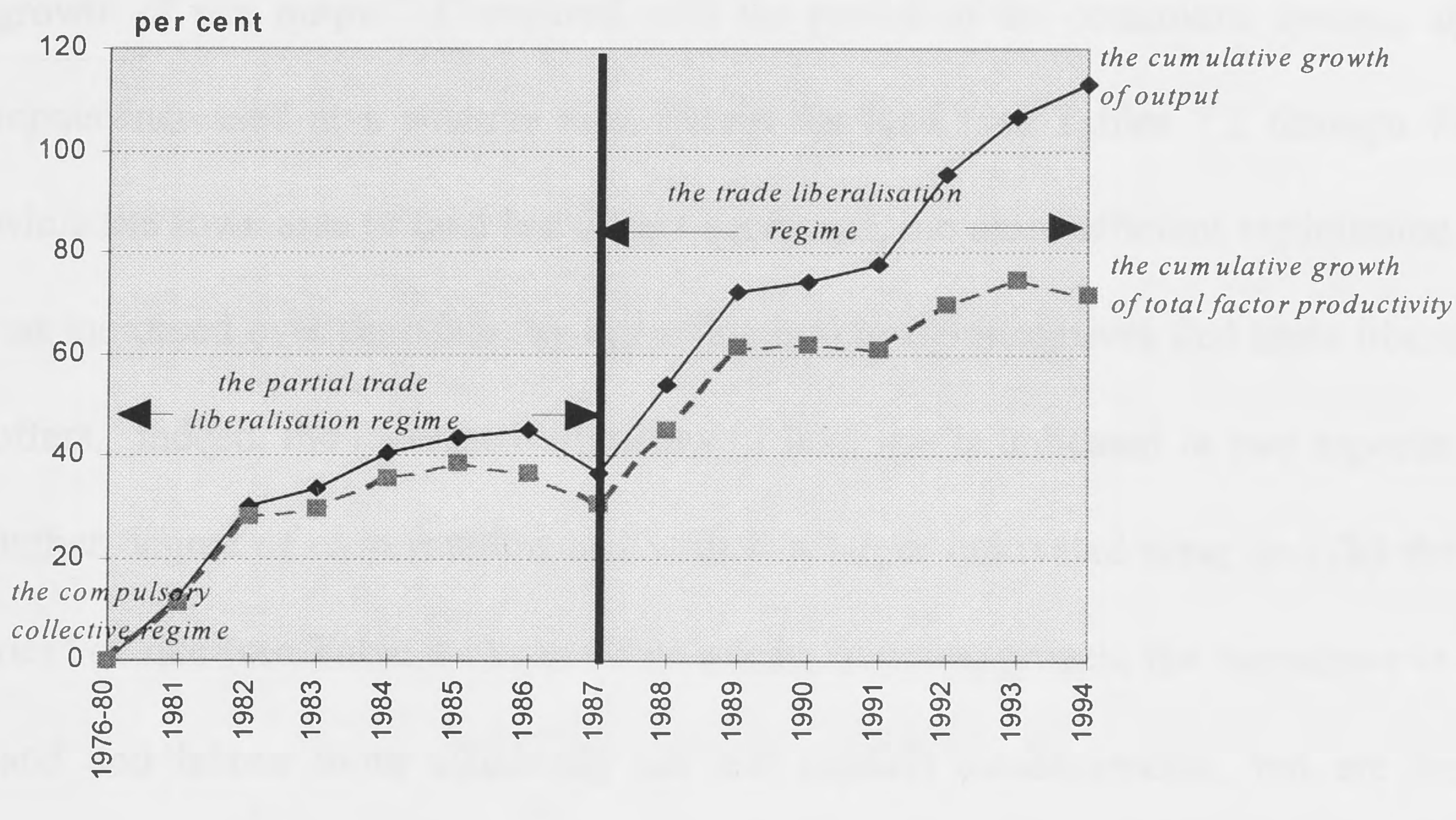
Note: *Annual growth rate is measured as the fitted value of the exponential growth rate*

***Table 7.4* The growth for total factor productivity in the transitional periods of trade liberalisation in the south, 1976-94** *(per cent)*

Year	The cumulative growth of the factor: (*the figure at 1976-80 as 100*)						Percentage of contribution of (g_A) in growth rate of output
	Output	Labour	Land	Current input	Capital	Total factor productivity	
	(g_Q)	(g_N)	(g_L)	$(g_{K(1)})$	$(g_{K(2)})$	(g_A)	$(g_A)/(g_Q)$
1976-80	0.0	0.0	0.0	0.0	0.0	0.0	
1981	13.5	2.7	-3.8	4.6	33.7	9.2	68.6
1982	33.0	4.2	-5.2	7.6	29.0	28.3	85.7
1983	38.6	1.6	-6.5	13.8	26.0	32.8	84.9
1984	50.5	3.8	-7.9	15.3	30.8	43.7	86.5
1985	55.0	3.7	-10.8	18.1	35.0	47.8	87.0
1986	57.6	5.2	-13.1	26.0	49.3	46.4	80.6
1987	46.0	1.7	-12.9	23.3	34.0	38.2	82.9
1988	66.5	5.7	-16.7	34.8	35.2	54.6	82.1
1989	89.6	10.6	-16.7	37.6	43.3	74.8	83.5
1990	98.4	14.9	-16.7	40.1	39.4	82.1	83.5
1991	116.2	14.2	-15.3	50.6	78.4	91.5	78.7
1992	121.7	28.1	-15.8	63.2	121.9	85.0	69.8
1993	124.3	25.9	-17.9	72.0	189.8	78.5	63.1
1994	133.4	30.9	-17.9	83.3	216.4	79.4	59.5
	Annual growth rate (per cent)						
	Output	Labour	Land	Current input	Capital	Total factor productivity	
1981-87	5.9	0.3	-2.0	3.3	3.4	5.2	
1988-94	6.5	3.7	-0.5	5.6	14.5	3.3	

Note: *Annual growth rate is measured as the fitted value of the exponential growth rate*

Figure 7.1: **The cumulative growth of output and total factor productivity for the rice industry in Vietnam**



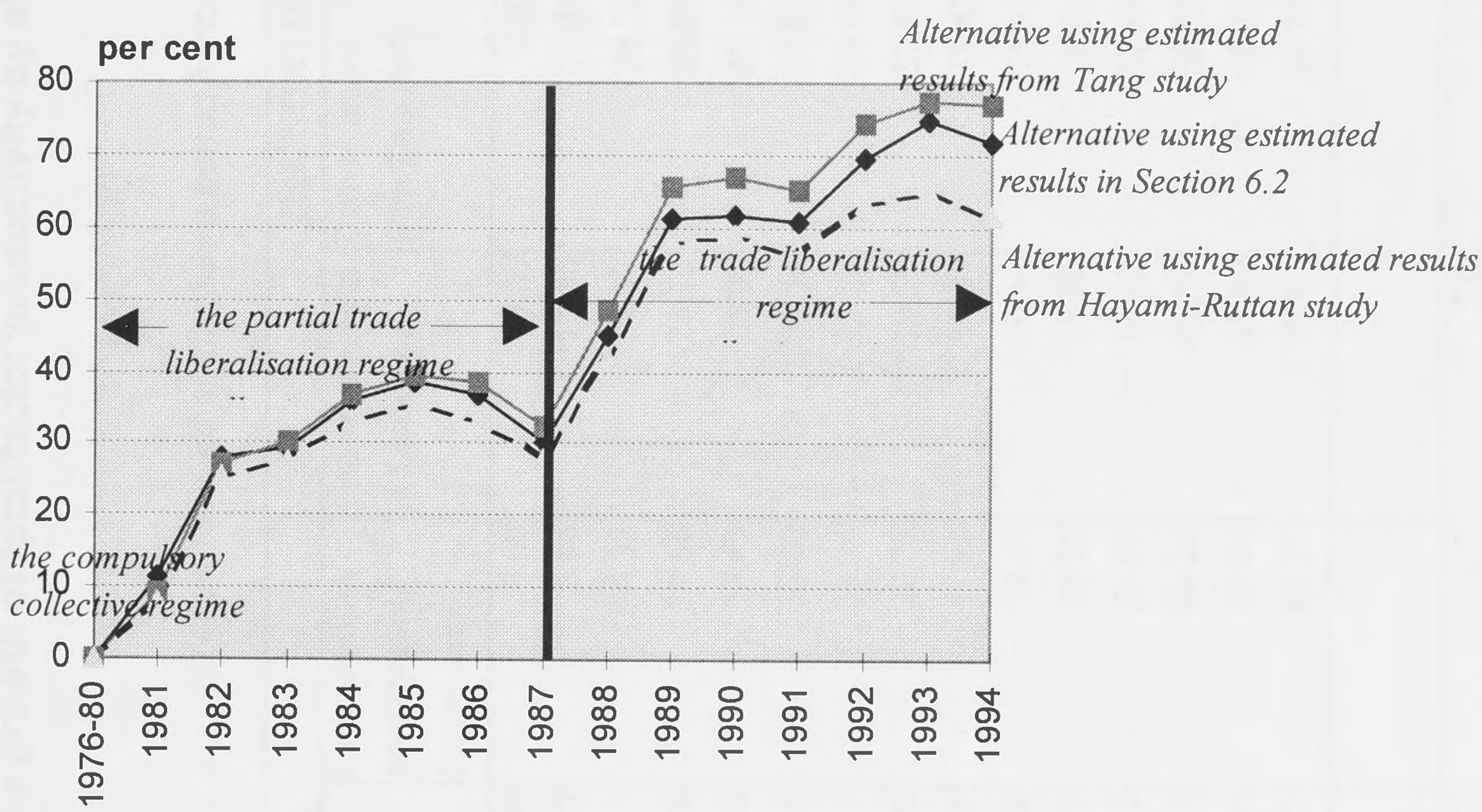
The positive growth rate of total factor productivity across periods of trade liberalisation (see Tables 7.2 to 7.4) can be explained by the enhanced incentive effects that accompany economic reform. Since there is no significant change in technology, it follows that without liberalisation, all other things equal, the growth rate of total factor productivity must be equal to zero or, in other words, the growth of output is due solely to the growth of inputs. However, under the effects of partial-liberalisation in the period 1981-87, total factor productivity grew at the annual rate 3.8, 2.0 and 5.2 per cent for Vietnam, the north and the south respectively. In the period of the freeing up of domestic and international markets (1988-94), rice output and total factor productivity rose comparatively much more. In this period, the annual growth rate of total factor productivity (instead of a zero growth rate if there is no further liberalisation), was 3.6, 3.3 and 3.3 per cent for Vietnam, the north and south respectively.

Besides the growth of total factor productivity, the growth of factor inputs, especially current inputs and capital, also contributed markedly to the remarkable growth of rice output. Compared with the period of the communal system, all factor inputs increased at a positive rate, except for land (see Tables 7.2 through 7.4), and while the sown area of land has in fact decreased, the more efficient exploitation of land has increased over time due (by our argument) to the incentives that trade liberalisation offers. Indeed, the increased efficiency of land use is indicated in two aspects: (a) the higher degree of crop rotation and with it a larger cultivated area; and (b) the higher yield of rice (see Table 6.1). In other words, in our approach, the incentives to exploit land and labour more efficiently are not explicit measurements, but are implicitly revealed through a large increase in growth of total factor productivity and the more efficient use of agricultural resources.

Obviously, the analysis of the growth of total factor productivity in the process of trade liberalisation above relies on the estimated results performed in Section 6.2. However, as a sensitivity check, an alternative measure of this growth rate can be obtained by using a different measure for the share parameters for inputs. Let the alternative measure be the estimated results obtained by Tang (1980) for China and Hayami and Ruttan (1985) for 22 other LDCs. In this case, the technical share parameters for labour, land, current input and capital are 0.5, 0.25, 0.1 and 0.15 for China (Tang, 1980, p.28), and 0.53, 0.1, 0.21 and 0.16 for 22 other LDCs (Hayami-Ruttan 1985, chap. 6). Accordingly, the institutional share parameters of inputs for China and 22 other LDCs can be computed according to the equations (3.22) through (3.25). Taking the value of the effort-disutility coefficient *(z)* to be 3, (see Appendix

7A), the institutional share parameters of inputs are computed to be 0.32; 0.34; 0.14 and 0.2 for China, and 0.4, 0.13, 0.27 and 0.21 for 22 other LDCs for labour, land, current input and capital respectively. Following an approach similar to that above, the alternative measure of the growth of total factor productivity for rice production is obtained and shown in Table 7.5. A comparison across all of these measures shows (clearly) that there is little difference in the results (see Table 7.5 and Figure 7.2).

Figure 7.2: **Comparison of the cumulative growth of total factor productivity by alternative measures of the share parameters of inputs**



In a nut shell, regardless of the approach taken, total factor productivity has been increasing simultaneously with the process and the extent of trade liberalisation, and the inspection of Tables 7.2 through 7.5 leaves little doubt that the growth in total factor productivity is the important explanation for the extremely high rates of growth of rice output in Vietnam from 1980 until the present.

Table 7.5 **Comparison of the cumulative growth of total factor productivity by alternative measures of the share parameters of inputs**

(per cent)

(Takes 1976-80 as the basis period for calculating)

Year	VIETNAM			THE NORTH			THE SOUTH		
	Estimated results in Section 6.2	Derived results from Tang study	Derived results from Hayami-Ruttan study	Estimated results in Section 6.2	Derived results from Tang study	Derived results from Hayami-Ruttan study	Estimated results in Section 6.2	Derived results from Tang study	Derived results from Hayami-Ruttan study
1976-80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1981	11.17	9.13	8.06	12.00	11.19	11.16	9.25	6.51	4.56
1982	28.09	27.11	25.32	27.37	26.72	26.03	28.25	26.52	23.82
1983	29.50	30.28	27.58	25.12	26.09	24.58	32.79	33.20	29.65
1984	35.84	36.58	33.43	25.07	26.20	24.44	43.74	43.70	39.45
1985	38.38	39.34	35.30	25.56	27.07	24.76	47.85	47.96	42.69
1986	36.69	38.30	33.26	22.26	24.49	21.98	46.44	46.85	39.81
1987	30.37	32.46	27.77	19.50	21.83	19.32	38.15	39.83	33.62
1988	44.83	48.46	41.94	30.21	33.43	30.09	54.59	58.43	49.60
1989	61.16	65.46	58.35	40.85	45.53	41.60	74.80	77.98	68.29
1990	61.65	66.88	59.22	32.56	38.36	33.66	82.11	85.83	75.52
1991	60.73	65.12	56.42	16.32	21.16	16.14	91.45	94.13	82.42
1992	69.55	74.31	63.24	43.53	50.33	42.57	84.97	84.89	69.89
1993	74.83	77.54	64.98	61.80	68.13	59.71	78.46	74.03	56.95
1994	71.53	76.83	61.57	52.91	64.19	52.33	79.40	74.64	55.42
Fitted annual growth rate									
1981-87	3.8	4.2	3.7	2.0	2.4	2.0	5.2	5.5	4.9
1988-94	3.6	3.7	3.0	3.3	3.9	3.2	3.3	2.6	1.6

7.2 Decomposition of total factor productivity growth into two components

Now consider the decomposition of total factor productivity growth into two components, one due to the effects of trade liberalisation alone, called (A_1), and one which includes a number of 'unexplained' causes, termed the so-called Solow residual (A_0). The computed value of A_1 thus indicates the extent to which trade liberalisation contributes to the growth of rice output through the growth of total factor productivity.

Following the analysis for the growth of factor productivity (A_1) in Chapter 4 above, the growth of A_1 is given as in equation (4.11), listed here again for convenience

$$\frac{\dot{A}_1}{A_1}=\left(\frac{\alpha_1+\alpha_2}{z-\alpha_1-\alpha_2}\right)\left[\frac{\dot{\beta p}}{\beta p}+\frac{(1-\dot{C_0 m})}{(1-C_0 m)}\right]. \tag{7.3}$$

For the case of rice production in Vietnam, we compute the value of $\left(\frac{\alpha_1+\alpha_2}{z-\alpha_1-\alpha_2}\right)\cong$ 0.3, where z=3, α_1=0.4, α_2=0.3; α_3=0.2 and α_4=0.1 (see Appendix 7A). Substituting the values of α_1, α_2, α_3 and α_4 into equation (3.8), the value of C_0 is approximately 1.4. The data source and the discussion of adjustment for the time series of the average rice price (βp), the average weighted cost share parameter (m) and (1-C_0m) are documented in the Data Appendix, Section DA.3. Substituting the results of time series for the average rice price (βp) and (1-C_0m) (see Tables DA.10 and DA.12, Data Appendix) into (7.2), gives the time-series data on the growth of βp and (1-C_0m) (see Table 7.6).

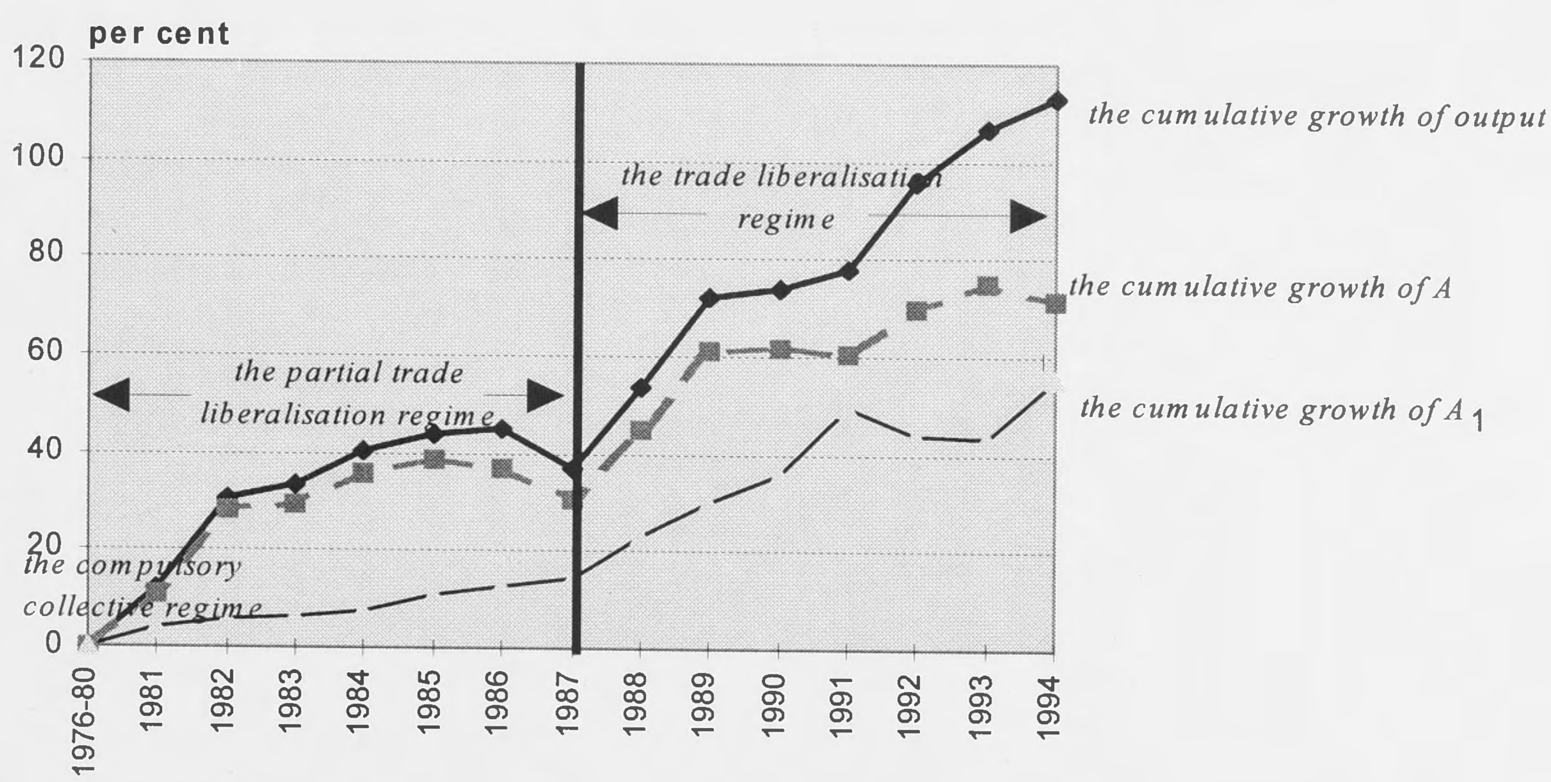
Following (7.3), the value of A_1 is computed from the growth of βp and (1-C_0m). The obtained value of A_1 (see Table 7.6) shows quantitatively the separate effects of liberalisation on the growth of total factor productivity in rice production.

Table 7.6 The cumulative growth of A_1 and the Solow residual *(per cent)*

	Cumulative growth of A			Cumulative growth of $(1\text{-}C_0m)$	Cumulative growth of βp			Cumulative growth of A_1			Solow residual			A_1 percentage share of total factor productivity growth		
	VN	**North**	**South**		**VN**	**North**	**South**	**VN**	**North**	**South**	**VN**	**North**	**South**	**VN**	**North**	**South**
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*9/2*	*10/3*	*11/4*
1976-80	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
1981	11.17	12.00	9.25	0.0	13.85	3.39	23.94	4.16	1.02	7.18	7.01	10.98	2.07	37.24	8.50	77.62
1982	28.09	27.37	28.25	0.0	18.33	8.52	27.86	5.50	2.55	8.36	22.59	24.82	19.89	19.58	9.32	29.59
1983	29.50	25.12	32.79	0.0	22.04	17.34	27.27	6.61	5.20	8.18	22.89	19.92	24.61	22.41	20.70	24.95
1984	35.84	25.07	43.74	0.0	25.55	17.76	33.58	7.66	5.33	10.07	28.18	19.74	33.67	21.37	21.26	23.02
1985	38.38	25.56	47.85	15.7	21.35	20.57	23.94	11.12	10.89	11.90	27.26	14.67	35.95	28.97	42.6	24.87
1986	36.69	22.26	46.44	15.7	27.42	33.26	25.24	12.94	14.69	12.29	23.75	7.57	34.15	35.27	65.99	26.47
1987	30.37	19.50	38.15	18.1	30.72	31.29	32.2	14.66	14.83	15.10	15.71	4.67	23.05	48.27	76.04	39.58
1988	44.83	30.21	54.59	18.1	58.55	78.73	45.75	23.00	29.06	19.16	21.83	1.15	35.43	51.31	96.21	35.10
1989	61.16	40.85	74.80	23.0	77.33	77.86	80.46	30.09	30.24	31.02	31.07	10.61	43.78	49.20	74.03	41.47
1990	61.65	32.56	82.11	24.2	94.29	93.39	99.71	35.53	35.27	37.16	26.12	0.00	44.95	57.63	100.00	45.26
1991	60.73	16.32	91.45	32.0	132.72	112.69	151.72	49.41	43.41	55.12	11.32	0.00	36.33	81.35	100.00	60.27
1992	69.55	43.53	84.97	33.8	112.1	103.89	122.77	43.77	41.31	46.97	25.78	2.22	38.00	62.93	94.90	55.28
1993	74.83	61.80	78.46	32.0	113.1	90.38	134.05	43.53	36.71	49.82	31.30	25.09	28.64	58.17	59.40	63.50
1994	71.53	52.91	79.40	30.2	153.79	153.65	158.66	55.19	55.15	56.66	16.34	0.00	22.74	77.15	100.00	71.36
Fitted annual growth rate																
1981-87	3.8	2.0	5.2	2.8	3.1	4.2	2.4	1.8	2.2	1.6	2.3	≅0.0	4.0			
1988-94	3.6	3.3	3.3	1.9	8.5	6.7	9.9	4.0	3.3	4.6	0.2	0.6	≅0.0			

As compared with the period of the communal system, in the period 1980-87 total factor productivity increased at the annual rates of 1.8, 2.2 and 1.6 per cent for Vietnam, the north and the south respectively. Under the effects of full trade liberalisation (the period 1988-94), total factor productivity increased at annual rates of 4.0, 3.3 and 4.6 per cent for Vietnam, the north and south respectively. Clearly, the stronger the process of trade liberalisation the higher the growth of total factor productivity. Total factor productivity jumped to a higher level when agriculture moved from the communal system to the output contracts system (1981-87), and jumped again dramatically after the full liberalisation of domestic and international markets (1988-94). The strong relation among the growth of output, total factor productivity (A) and the part of total factor productivity resulting from effects of liberalisation (A_1) in 1976-94 also can be seen graphically in Figure 7.3 below.

Figure 7.3: **The cumulative growth of output, total factor productivity (A) and the part of total factor productivity due to liberalisation (A_1) in Vietnam**



A regional comparison also shows that total factor productivity increased more in the south than in the north, where the push for trade liberalisation was effectively more determined and vigorous. Indeed, the ratio of the cumulative growth of A_1 to that of A also broadly reflects the extent of trade liberalisation; for the whole of the country it has increased from 37.2 per cent in 1981 to 77.5 per cent in 1994 (see Table 7.6).

7.3 Concluding remarks

This chapter has provided a quantitative analysis of the effects of liberalisation on the growth of rice production as a result of the growth of total factor productivity. Whether one uses the estimated results constructed in Section 6.2 or the alternatives measures from other empirical studies, the conclusion is still the same. Total factor productivity has been increased directly in line with the pace and progress of trade liberalisation and the growth in factor productivity is the most important reason for the remarkable growth of rice output in the years 1980 to 1994. Indeed, the growth in total factor productivity more than dominates the effect of increases in factor supplies.

Appendix 7A: THE CALCULATION OF THE EFFORT-DISUTILITY COEFFICIENT (Z) AND THE 'TECHNICAL' SHARE PARAMETERS FOR INPUTS

The value of z can be derived directly from equation (3.21) or (4.10) with a knowledge of the components of βp. However, some parameters (such as A, α_i and δ) in these equations are unknown. To simplify, we calculate z from the growth rate of A and βp in two contiguous years within the same period of liberalisation so that the value of $(1\text{-}C_0 m)$ does not vary much. Thus, from (3.21) it can be seen that

$$\frac{\alpha_1 + \alpha_2}{z - (\alpha_1 + \alpha_2)} = \frac{(\dot{A} / A)}{(\dot{\beta p} / \beta p)} \tag{7A.1}$$

Take the years 1979 and 1978 from the period of the output-contracts so that, by assumption, the average weighted cost share parameters and the market share coefficient in these years are the same.[3] From equation (7A.1), we obtain

$$\frac{\dot{A}}{A} = \frac{z - \alpha_1 - \alpha_2}{\alpha_1 + \alpha_2}\left[\frac{\beta p^{1979}(1 - C_0 m) - \beta p^{1978}(1 - C_0 m)}{\beta p^{1978}(1 - C_0 m)}\right]. \tag{7A.2}$$

The value of the growth rate of total factor productivity between 1978 and 1979 is 0.078. The growth of the price of rice is 0.25 (calculated from Table S.4, Sub Appendix, Data Appendix). Thus, from (7A.2)

$$\frac{\alpha_1 + \alpha_2}{z - (\alpha_1 + \alpha_2)} \cong 0.3\,. \tag{7A.3}$$

Substituting the value of equation (7A.3) into equations (3.22) to (3.25), and solving the simultaneously, with the constraint $z > 1$ as in Chapter 3 above, gives: $z \cong 2.8$; $\alpha_1 \cong 0.4$; $\alpha_2 \cong$

[3]The output in 1978 is adjusted by adding the amount of output which was destroyed by bad weather in that year (DAFF, GSO, 1996).

0.3; $\alpha_3 \cong 0.2$ and $\alpha_4 \cong 0.1$. Alternatively, choosing, the years 1982 and 1983 gives a growth rate of total factor productivity of 0.07 and the growth rate of the price of rice price at 0.183, so that

$$\frac{\alpha_1 + \alpha_2}{z - (\alpha_1 + \alpha_2)} \cong 0.38. \tag{7A.4}$$

As above, the calculated results are: $z \cong 3.3$; $\alpha_1 \cong 0.4$; $\alpha_2 \cong 0.3$; $\alpha_3 \cong 0.2$ and $\alpha_4 \cong 0.1$. From the two attempts it can safely be assumed that the value of z is about 3 and $\alpha_1 \cong 0.4$; $\alpha_2 \cong 0.3$; $\alpha_3 \cong 0.2$ and $\alpha_4 \cong 0.1$. From equation (3.8), the value of C_0 is computed to be 1.4.

Chapter 8

AN EMPIRICAL ANALYSIS OF THE TRANSITIONAL PATH AND THE LONG-RUN STEADY STATE VALUE OF RICE PRODUCTION

This chapter uses the dynamic model of internal and external trade liberalisation developed in Chapter 5 as the basis for an empirical analysis of the transitional dynamic path and long-run level of capital and output for the rice industry in Vietnam. The chapter is divided into four sections. Section 8.1 discusses a graphical comparison of the actual transitional path with the path predicted by the theory for rice production. This suggests an underlying consistency between the theory and the empirical evidence. Based on the theoretical analysis in Chapter 5 and given parameter values relevant to Vietnam, Section 8.2 computes the various steady-state values of capital in the periods of trade liberalisation. Section 8.3 provides an empirical estimate of the speed of convergence in the dynamic model and the timescale required for the rice industry to reach the neighbourhood of a steady-state. Section 8.4 estimates the long-run level of output and the capital stock in the rice industry in the different stages of trade liberalisation, and Section 8.5 provides some concluding remarks. Appendix 8A collects all of the technical details, showing clearly the derivation of the appropriate linear approximation of the underlying dynamic model.

8.1 The transitional paths for the capital stock and output in rice production

Both the theoretical and empirical transitional paths for the capital stock and the output of rice production will be represented graphically in this section. While the dynamic model of Chapter 5 is clearly helpful in predicting the behaviour of capital and rice output along a transitional path under the various effects of trade liberalisation, the specific case of Vietnam allows us to see what actually happened under the liberalisation process and compare it with the predictions of the theory.

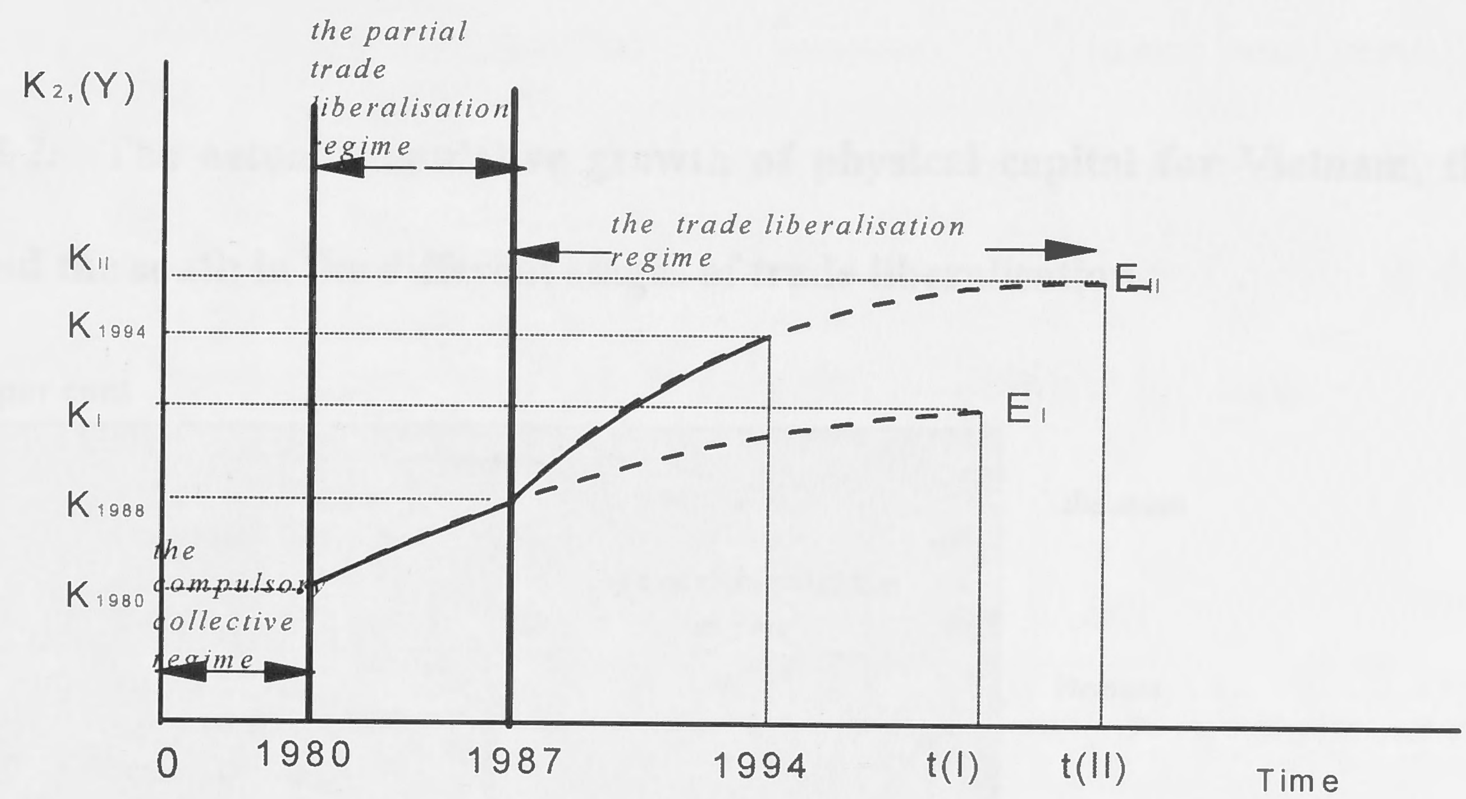
(a) The transitional dynamic path for physical capital

As outlined in Section 2.2, Chapter 2 above, the process of liberalisation in Vietnam started from the period of a communal system (1980) and continued through the period of de-collectivisation in rural areas with tightly controlled markets (1981-87), to the period of the total freeing up of markets, or market liberalisation (1988- to the present). Applying the phase diagram analysis of Figure 5.2, from Chapter 5, to rice production in Vietnam, the theoretical trend of physical capital is indicated in Figure 8.1. As such, K^{1980}, K^{1988}, and K^{1994} represent the values of physical capital for the rice industry in years in which the important stages of liberalisation occurred.[1] The years 1980 and

[1] Chapter 5 referred to the capital-labour ratio rather than the capital stock. In order to eliminate the effect of growth in labour force on capital stock, for the precise comparison, it is assumed that total labour in the sector does not change so that the analysis for the capital-labour ratio can be applied for the capital stock.

1987 are the first year for the period of output contracts and the commencing year of the period of the opening up of markets respectively and 1994 is the last year for data source used in this dissertation. The length of time from 1981 to the year *t(I)* is the timescale required for the rice industry to attain the vicinity of the steady state in the period of output contracts, and *t(II)* is the year in which the steady state is nearly attained for the period of the opening up of markets.[2]

Figure 8.1: **The theoretical path of physical capital for the rice industry in the different stages of trade liberalisation**

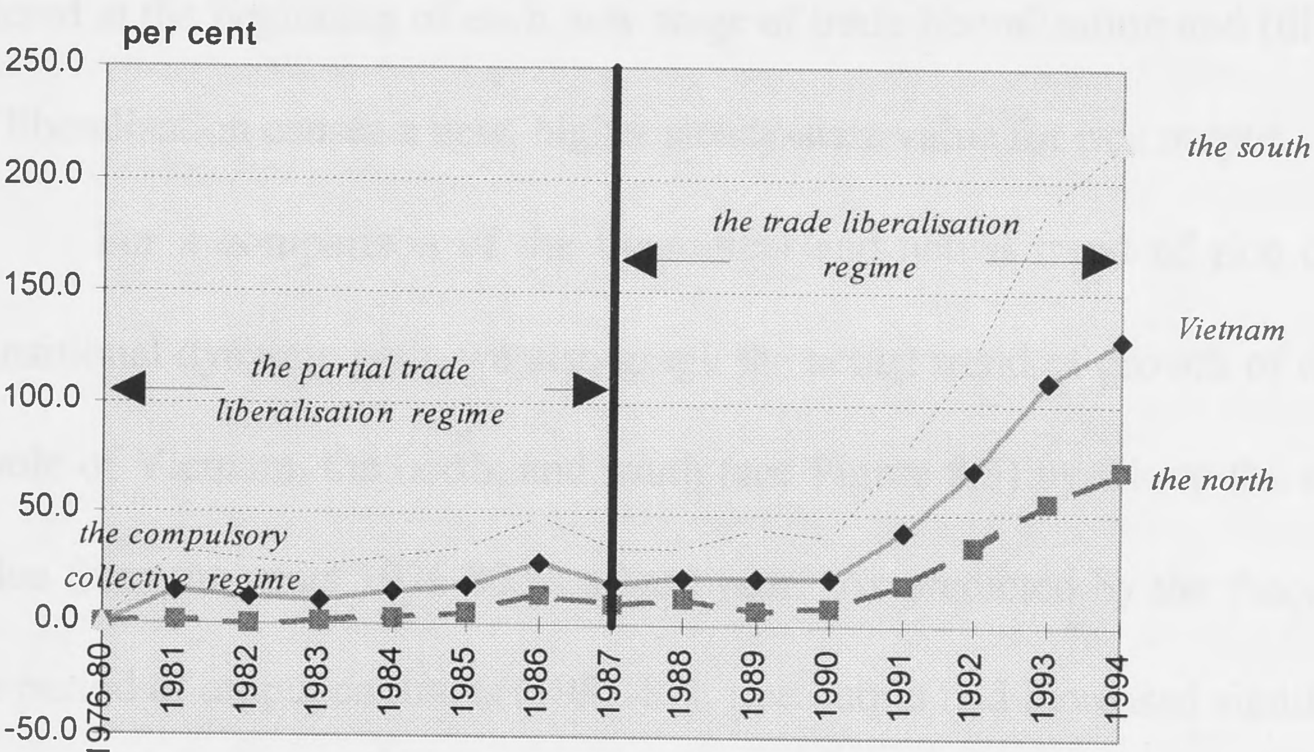


According to Figure 8.1, in a given period of trade liberalisation, capital is increasing monotonically and converging to its steady-state value. At the beginning of each transition or the next stage of trade liberalisation, the rate of change of capital jumps up to a higher level. As a result, each new stage of liberalisation results in a new, higher steady-state level for physical capital.

[2]In principle, an infinite timescale is required for the system to converge to the steady state.

Returning to the actual facts of the rice industry in Vietnam, we would like to know whether the actual trend of capital is consistent with the theoretical analysis as illustrated in the graph above. The time series data for physical capital is available (Tables 7.1), and thus it is possible to graph (see Figure 8.2) the trends of growth of physical capital during the liberalisation process (taking the value of physical capital in the period of the communal system (1976-1980) as a basic index). As seen, the value of physical capital for rice production in Vietnam increased moderately in the period of output contracts (1981-87), and has increased remarkably since the opening up of markets, or 1988 to the present.

Figure 8.2: **The actual cumulative growth of physical capital for Vietnam, the north, and the south in the different stages of trade liberalisation**



Sources: *Constructed data from the Statistics Department of Agriculture, Forestry and Fishing (SDAFF)-General Statistics Office (GSO) (see Section DA.2, Data Appendix)*

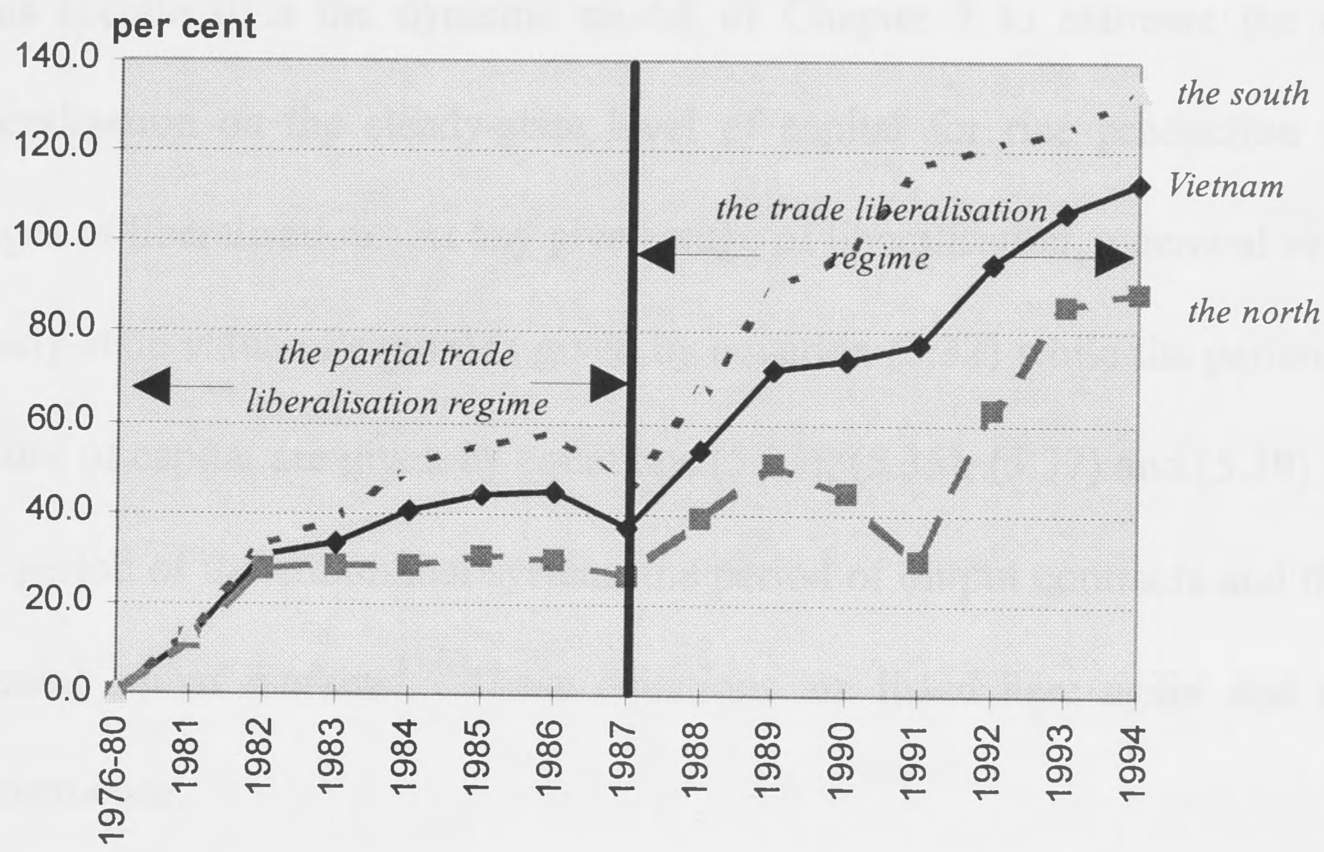
The comparison of the theoretical trends of physical capital in Figure 8.1 and the actual data in Figure 8.2 suggests that the theoretical analysis is broadly consistent with the empirical evidence in the rice industry for the whole of Vietnam as well as for the north and south separately.

(b) The transitional path for rice output

Since the output of rice can be derived from the institutional production function in equation (3.20), it is easy to show that the theoretical trend of rice output must follow a similar path to that illustrated for physical capital in Figure 8.1. On this basis, the transitional path for rice output follows the characteristics that: (i) in one given period of trade liberalisation the trend for rice output is increasing monotonically and converging to a steady state; (ii) rice output jumps to a higher level and its rate of change is also altered at the beginning of each new stage of trade liberalisation and (iii) each new stage of liberalisation causes a new, higher steady-state value for rice output.

For a comparison of the theoretical and actual trend of rice output along the transitional dynamic path, we also graph the actual trend of growth of rice output in the whole of Vietnam, the north, and south (see Figure 8.3) by taking the numerical mean-value from the years 1976-80 as a base year. As predicted by the theoretical model, in the period of output contracts (1981-87), rice output had increased significantly and then it jumps remarkably in the period of market liberalisation or the opening up of markets (1988 to the present). Each new stage of liberalisation causes a new, higher level of the trend value for rice output for Vietnam as well as for the north and south taken separately.

Figure 8.3: **The actual cumulative growth of rice output for Vietnam, the north and the south in the different stages of trade liberalisation**



Sources: *The Statistics Department of Agriculture, Forestry and Fishing (SDAFF)-General Statistics Office (GSO).*

To reiterate, the comparison between Figures 8.1 and 8.3 shows (at least casually) a clear consistency between the prediction of the theoretical analysis and the actual time path of rice output in Vietnam. The general consistency between the predicted and observed transitional paths over the process of trade liberalisation provides some reassurance about the usefulness of the model of Chapter 5 as a predictor of the steady-state level of rice output and capital stock in Vietnam. In the remainder of this chapter, the model will be used as a basis for empirical estimation of the long-run growth path in transition to the respective steady states.

8.2 The steady-state values of physical capital in the different stages of trade liberalisation

This section uses the dynamic model of Chapter 5 to estimate the effects of trade liberalisation on the steady-state level of capital for rice production in the different stages of liberalisation. At any given stage of liberalisation, a general expression for the steady-state value of capital is given by equation (5.32) while the particular steady-state values of capital are given by equations (5.33), (5.35), (5.37) and (5.39) respectively for the period of the communal system, the period of output contracts and the period of the opening up of markets[3]. These equations are listed here again and renumbered for convenience.

In the communal system, the steady-state physical capital (k_2^0) is given by

$$k_2^0 = \left\{ \frac{(p_s(1-C_0 m_c)\alpha_0 l^{\alpha_2} k_1^{\alpha_3})^{\frac{z}{z-\alpha_1-\alpha_2}} \delta^{\frac{\alpha_1+\alpha_2}{z-\alpha_1-\alpha_2}} \alpha_1^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}} \alpha_2^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}} \alpha_4^{1+\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}}{(\mu+n+\rho)\left[(1-\alpha_4)(\mu+n)+\rho\right]^{\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}} \right\}^{\frac{1}{(1-\gamma_4)+\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}} \tag{8.1}$$

In the period of output contracts with tightly controlled domestic markets, the steady-state physical capital (k_2^I) is

$$k_2^I = \left\{ \frac{\left[(\beta_0^D p_s + \beta_1^D p_M)(1-C_0 m_D)\alpha_0 l^{\alpha_2} k_1^{\alpha_3} \right]^{\frac{z}{z-\alpha_1-\alpha_2}} \delta^{\frac{\alpha_1+\alpha_2}{z-\alpha_1-\alpha_2}} \alpha_1^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}} \alpha_2^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}} \alpha_4^{1+\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}}{(\mu+n+\rho)\left[(1-\alpha_4)(\mu+n)+\rho\right]^{\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}} \right\}^{\frac{1}{(1-\gamma_4)+\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}} \tag{8.2}$$

[3] Section 2.2 discusses the period of the opening up of the domestic market as well as the period of the opening up of the international market in Vietnam, both of which happened nearly simultaneously in the period from 1988-1989.

and in the period of the opening up of markets, the steady-state physical capital (k_2^{II}) is

$$k_2^{II} = \left\{ \frac{\left[(\beta_1^W p_M + \beta_2^W p_W)(1 - C_0 m_W)\alpha_0 l^{\alpha_2} k_1^{\alpha_3} \right]^{\frac{z}{z-\alpha_1-\alpha_2}} \delta^{\frac{\alpha_1+\alpha_2}{z-\alpha_1-\alpha_2}} \alpha_1^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}} \alpha_2^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}} \alpha_4^{1+\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}}{(\mu+n+\rho)\left[(1-\alpha_4)(\mu+n)+\rho\right]^{\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}} \right\}^{\frac{1}{(1-\gamma_4)+\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}} \tag{8.3}$$

It is possible to use these expressions to estimate the steady-state level of capital at each stage of liberalisation, assuming the values of the parameters as determined in Chapters 6 and 7, with the exception of δ and ρ.[4] However, there is a simple method of computing these steady-state values using a historically pre-determined value of K_2^0. Since Vietnam had already experienced a collective regime for a long period of time, especially in the north where collectivism was firmly in place for at least twenty five years, assume that for the period from 1976 to 1980, agriculture had already attained a steady-state equilibrium for the period of the communal system. If so, we can take the arithmetic mean of physical capital during 1976-80 as representing the steady-state value of capital at this time and in this system. According to Table 7.1, the steady-state physical capital in the period of the communal system is 245.5, 146.4 and 99.1 ten thousands horsepower for Vietnam, the north and south respectively.

From equations (8.1) and (8.2), the steady-state value of physical capital in the period of output contracts with tightly controlled markets then can be derived as

$$K_2^I = K_2^0 \left[\frac{(\beta_0^D p_S + \beta_1^D p_M)(1 - C_0 m_D)}{p_S(1 - C_0 m_C)} \right]^{\frac{1}{(1-\gamma_4)+\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}} \tag{8.4}$$

---

[4] As mentioned in footnote (3), in this chapter, although equations (8.1) to (8.3) are expressed in terms of capital-labour ratio, here we eliminate the effect of growth in the labour force on the capital stock by assuming that the total labour input does not change so that the analysis for the capital-labour ratio can be replicated in terms of the capital stock.

Here, $\gamma_4 \cong 0.1$ (see Section 6.2, Chapter 6), $z \cong 3$, $\alpha_1 \cong 0.4$, $\alpha_2 \cong 0.3$, $\alpha_3 \cong 0.2$ and $\alpha_4 \cong 0.1$ (see Appendix 7A). Following the discussion in Section 5.4 (Chapter 5) about the value of the constant intertemporal elasticity of consumption σ in relation to α_4, we assume that in this case the value of σ is equal to the value of α_4, or 0.1. Substituting these values into equation (8.4), we get

$$\left(\frac{1}{(1-\gamma_4)+\dfrac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}\right) \cong \left(\frac{1}{(1-0.1)+\dfrac{0.1(0.3+0.4)}{3-0.3-0.4}}\right) \cong 1.1 \qquad (8.5)$$

Now assume that the structure and price level in the goods and factor markets are constant from 1987 to the year of the steady state, so that we can use the values of the average rice price $(\beta_0^D p_S + \beta_1^D p_M)$ and the composite measure $(1 - C_0 m_D)$ in 1987 to represent steady-state values. From Table DA.10 (see Data Appendix), the ratio between the average rice price in the period of output contracts and that in the period of the communal system $\left(\dfrac{\beta_0^D p_s + \beta_1^D p_M}{p_s}\right)$ is derived to be approximately 1.31[5] and the ratio $\left(\dfrac{1-C_0 m_D}{1-C_0 m_C}\right)$ between the period of output contracts and the period of the communal system is approximately 1.09.[6]

Substituting the value of K_2^0 (245.5, 146.4 and 99.1 ten thousands horsepower for Vietnam, the north and south respectively (derived from Table 7.1) and the values of coefficients and the ratios above into equation (8.4), we get the steady-state values of

[5] Data sources and adjustments are documented in Data Appendix (Section DA.3 and Table DA.10). For simplification, we assume that ratio for the whole of Vietnam is the same for the north and south.
[6] Data sources and adjustments are documented in Data Appendix (Section DA.3 and Table DA.10. Again, for simplification, we assume that ratio for Vietnam is the same for the north and south.

physical capital in the period of output contracts to be 363.2, 216.7 and 146.7 ten thousands horsepower for Vietnam, the north and south respectively (see Table 8.1).

Table 8.1 **The steady-state value of capital in the different stages of trade liberalisation** (*Ten thousands horsepower)*

	The stage of trade liberalisation	VIETNAM	The north	The south
(0)	The period of the communal system	245.5	146.6	99.1
(I)	The period of output contracts with a tightly controlled market	363.2	216.7	146.7
(II)	The period of the opening up of the domestic and international markets	844.0	503.6	340.9

Following a similar approach to that above, the steady-state value of physical capital in the period of the opening up of markets also can be derived. From equations (8.1) and (8.2), the steady-state physical capital in this period is found to be

$$K_2^{II} = K_2^0 \left[\frac{(\beta_1^W p_S + \beta_2^W p_M)(1 - C_0 m_W)}{p_S(1 - C_0 m_C)} \right]^{\frac{1}{(1-\gamma_4)+\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}}} . \tag{8.6}$$

Here, the superscript in (8.6) is given as in (8.5) and is approximately 1.1.

Again, it is assumed that the structure and price level in the goods and factor markets are constant in the period from 1994 to the year of the steady state. As above, we use the value of average rice price $(\beta_0^D p_S + \beta_1^D p_M)$ and $(1 - C_0 m_D)$ in 1994 for those values in the year of the steady state. Based on Table DA.10 (Data Appendix), the ratio between the average rice price in the period of the opening up markets and that in the period of the communal system $\left(\dfrac{\beta_0^D p_s + \beta_1^D p_M}{p_s}\right)$ is computed to be approximately 2.54[7] and the ratio $\left(\dfrac{1 - C_0 m_D}{1 - C_0 m_C}\right)$ between the period of output contracts and the period of the communal system is approximately 1.21.[8]

Substituting the derived values of K_2^0 and the relevant coefficients and the ratios above into equation (8.6), we get the steady-state values of physical capital in the period of output contracts as 844.0, 503.6 and 340.9 ten thousands horsepower for Vietnam, the north and south respectively (see Table 8.1).

8.3 The speed of convergence and the timescale required for the system to reach the vicinity of the steady state

It is quite clear that the value of capital and rice output change considerably over time along a transitional path, but how quickly those variables change or how soon the rice industry will reach a neighbourhood of the steady state in a given stage of trade liberalisation is an important question we should now explore. Accordingly, this section is devoted to estimation of the speed of convergence of a transitional dynamic path and the timescale required for the rice industry to be within a vicinity of the steady state. In addition, the timescale of our model is also needed to derive the steady-state level for rice output in the different stages of trade liberalisation and to get some idea of the average annual growth rates predicted for the respective transitional periods.

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[7] Data sources and adjustments for this calculation are documented in Section DA.3 and Table DA.10 (Data Appendix).

[8] Data sources and adjustments for this calculation are documented in Section DA.3 and Table DA.10 (Data Appendix).

Here the standard approach of a log-linear approximation around steady-state values is used to generate numerical solutions of the approximate nonlinear system (see, for example, Barro and Sala-i- Martin (1995, p.59-92).[9]

The relevant system of simultaneous differential equations in consumption *(c)* and capital (k_2) is given by equations (5.25) and (5.29), renumbered here for convenience

$$\dot{k}_2(t) = f(c(t), k_2(t) = c(t)^{\frac{-\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}} B_4 k_2(t)^{\frac{z\alpha_4}{z-\alpha_1-\alpha_2}} - (\mu+n)k_2(t) - c(t) - \beta pd \tag{8.7}$$

$$\dot{c}(t) = g(c(t), k_2(t)) = \frac{1}{\sigma}\left[c(t)^{\frac{-\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}+1} B_4 \alpha_4 k_2(t)^{\frac{z\alpha_4}{z-\alpha_1-\alpha_2}-1} \right] - \frac{1}{\sigma} c(t)(\mu+n+\rho) \tag{8.8}$$

where B_4 is given as in equation (5.22), or

$$B_4 = \delta^{\frac{\alpha_1+\alpha_2}{z-\alpha_1-\alpha_2}} B_3^{\frac{z}{z-\alpha_1-\alpha_2}} \alpha_1^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}} \alpha_2^{\frac{\alpha_2}{z-\alpha_1-\alpha_2}}. \tag{8.9}$$

Taking a linear approximation around a steady-state point (c^*, k_2^*), gives, in matrix notation

$$\begin{bmatrix} \dot{k}_2(t) \\ \dot{c}(t) \end{bmatrix} = \begin{bmatrix} f_{k_2(t)} & f_{c(t)} \\ g_{k_2(t)} & g_{c(t)} \end{bmatrix} \begin{bmatrix} k_2(t) - k_2^*(t) \\ c(t) - c^*(t) \end{bmatrix} \tag{8.10}$$

where $f_{k_2(t)}$, $f_{c(t)}$, $g_{k_2(t)}$ and $g_{c(t)}$ are partial derivatives evaluated at the steady state.

The details of solution of the system (8.10) are presented in Appendix 8A. The resulting solution for the time path of the physical capital-labour ratio is found to be

[9] For simplification we use the derived result for the whole of Vietnam as applying to both the north and the south, i.e., we assume that it takes the same timescale for Vietnam, the north and south to reach the vicinity of the steady state.

$$k_2^t(t) = k_2^C + \bar{k}_2 = a_1 e^{-0.25t} + 0.97 k_2^*$$

where k_2^C represents the solution for the homogenous form of (8.10) and $\bar{k}_2$ is a particular solution of (8.10). As argued above, by assuming a constant labour input, it is possible to recast the foregoing equation to represent the time path of the absolute physical capital stock (or non-per-capita) which is then given by

$$K_2^t(t) = K_2^C + \bar{K}_2 = a_1 e^{-0.25t} + 0.97 K_2^*. \tag{8.11}$$

Thus the speed of convergence of capital is calculated as -0.25 for any stage of trade liberalisation. It is easy to show that the speed of convergence of output is the same as it is for capital (from the institutional production function), so the speed of convergence of rice output must also be -0.25.

As such, equation (8.11) only provides the general form of the time path for physical capital, in this (again) the speeds of convergence of capital and output are fixed at -0.25. But, obviously, the values of $\bar{K}_2$ or (K_2^*) and a_1 in (8.11) also depend on the relevant parameters, which vary in the different stages of liberalisation. In other words, for every period of liberalisation, we need to calculate the new and different time path of physical capital and the different length of time required for the rice industry to attain the vicinity of the steady state. These calculations are performed below for each of the two liberalisation stages.

(a) In the period of output contracts with tightly controlled markets

The value of a_1 can be computed by setting t=0 in equation (8.11) above. That value is given as

$$a_1 = K_2(0) - \bar{K}_2 = -106.8 \tag{8.12}$$

where $\bar{K}_2$ is computed as being 352.3 ten thousands horsepower[10] and $K_2(0)$ equals 245.5 ten thousands horsepower (Table 8.1).

Substituting the values of a_1 and $\bar{K}_2$ into (8.11), the time path for physical capital in this period is

$$K_2^t(t) = (-106.8)e^{-0.25t} + 352.3. \tag{8.13}$$

Now consider this approximate solution of the system at time *t*, when the system is in the neighbourhood of the steady state. Let ξ denote the proportion of the total adjustment (from time zero to the steady state) of $K_2^t(t)$ still to be effected at time *t*; i.e., ξ is given by

$$\frac{K_2(t) - K_2^*}{K_2(0) - K_2^*} = \xi. \tag{8.14}$$

Assume that we are interested in finding out the time taken for $K_2^t(t)$ to complete 90 per cent of the adjustment to the steady state, then ξ is 0.1. Substituting the value of $K_2(0)$, K_2^*, and (8.13) into (8.14), the value of *t* can be found to be

$$t = \frac{1}{0.25}\ln\left(\frac{106.8}{0.1 * 117.7 - 10.9}\right) \cong 20 \text{ years}. \tag{8.15}$$

Since the overall convergence time *T* may be approximated by *t* divided by (1-ξ), we obtain 22 years as the timescale required for the system to attain the vicinity of the steady state in this transitional period.

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[10]This value equals 0.97 K_2^* as given in (8.11), where K_2^* =363.2 ten thousand horsepower (see Table 8.1).

(b) In the period of the opening up of markets

Using the above approach, the value of a_1 in this case is

$$a_1 = K_2(0) - \bar{K}_2 = -818.7 \tag{8.16}$$

where in this period $\bar{K}_2$ is computed as being 818.7 ten thousands horsepower[11] and $K_2(0)$ (in the year 1987) equals 292.1 ten thousands horsepower (see Table 7.1).

Substituting the values of a_1 and $\bar{K}_2$ into (8.11), the time path for physical capital in this stage is given by

$$K_2^t(t) = (-818.7)e^{-0.25t} + 818.7. \tag{8.17}$$

By symmetry to the argument above regarding the relationship between the values of capital and the length of time required for the system to attain those values, we can use the relationship in equation (8.14) to determine the timescale in this period. Assume that ξ is 0.1 and substituting the value of $K_2(0)$, K_2^*, and equation (8.17) into (8.14), the value of t can be derived as

$$t = \frac{1}{0.25}\ln\left(\frac{818.7}{0.1 * 551.9 - 25.32}\right) \cong 13 \text{ years} \tag{8.18}$$

Again, approximating T by t divided by (1-ξ), the timescale required for the system to reach the vicinity of the steady state in this period is computed to be about 15 years.

8.4 The long-run level of rice output in the different stages of trade liberalisation

Now consider the steady-state value of rice output. As an important final good, the value of rice output, as it varies across different transitional periods, illustrates nicely the

[11] Equals 0.95 k_2^* (as in (8.11), where k_2^* =844.0 ten thousand horsepower (see Table 8.1).

distinct effects of market liberalisation and as such is a useful measure of particular interest to policy-makers in Vietnam.

In the steady state, if inputs are known, rice output can be computed by the institutional production function given in equation (3.20), or

$$Q^S = A(N^S)^{\gamma_1}(L^S)^{\gamma_2}(K_1^{\ S})^{\gamma_3}(K_2^{\ S})^{\gamma_4} \tag{8.19}$$

where Q^S, L^S, K_1^S and K_2^S are the steady-state values of labour, land, current input and physical capital respectively. Here γ_1 =0.2, γ_2 =0.4, γ_3 =0.4 and γ_4 =0.1 (see Table 6.4).

The total productivity factor coefficient A is still determined by the equation (3.21) or

$$A = (\alpha_0)^{\frac{z}{z-\alpha_1-\alpha_2}}\left[\ \delta\beta p(1-C_0 m)\ \right]^{\frac{\alpha_1+\alpha_2}{z-\alpha_1-\alpha_2}}(\alpha_1)^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}}(\alpha_2)^{\frac{\alpha_2}{z-\alpha_1-\alpha_2}} \tag{8.20}$$

Thus, total factor productivity depends on the component $\delta\beta p(1-C_0 m)$, which as discussed reflects the changes in market structure and the prices of goods and factors in the different stages of liberalisation.

We are now in a position to use equations (8.19) and (8.20) to estimate the steady-state level of rice output in the different periods of liberalisation.

(a) The steady-state level of rice output in the period of output contracts with tightly controlled markets

As we have seen, the timescale for long-run growth in this period is about 22 years. Thus if the system started in 1980, it will converge 'near' the steady state in the year 2002, and recall that the actual last year of the period of output contracts (1987) is the seventh year in that path.

The steady-state value of the parameters in equation (8.19) can thus be derived from their actual value at the seventh year of the process (or 1987) and applying the annual growth rate of those parameters for the 15 years from 1987 to 2002 (the year of the 'near' steady state). Equation (8.19) for steady-state rice output then can be rewritten as

$$Q = A^{1987}\left(\frac{100+g_A}{100}\right)^{15}\left(N^{1987}\right)^{\gamma_1}\left[\left(\frac{100+g_N}{100}\right)^{15}\right]^{\gamma_1}(L^{1987})^{\gamma_2}\left[\left(\frac{100+g_L}{100}\right)^{15}\right]^{\gamma_2}(K_1^{\ 1987})^{\gamma_3}$$
$$\left[\left(\frac{100+g_{K1}}{100}\right)^{15}\right]^{\gamma_3}(K_2^{\ 1987})^{\gamma_4}\left(\frac{K_2^S}{K_2^{1987}}\right)^{\gamma_4} \tag{8.21}$$

where g_A, g_N, and g_L are the respective annual growth rates of total factor productivity, labour, land, current input and physical capital from 1987 to 2002.

Based on the institutional production function in equation (8.19) for the year 1987, equation (8.21) can be rewritten as

$$Q = Y^{1987}\left(\frac{100+g_A}{100}\right)^{15}\left[\left(\frac{100+g_N}{100}\right)^{15}\right]^{\gamma_1}\left[\left(\frac{100+g_L}{100}\right)^{15}\right]^{\gamma_2}\left[\left(\frac{100+g_{K1}}{100}\right)^{15}\right]^{\gamma_3}\left[\frac{K_2^S}{K_2^{1987}}\right]^{\gamma_4} \tag{8.22}$$

where the annual growth rates for labour and current input are estimated to be approximately 0.6 and 3.1 per cent respectively in 1976-94 (see Table 7.1 for the whole of Vietnam), since, *ceteris paribus*, it is simply assumed that those growth rates are also the same in the period 1988-2002.

For simplification, also assume that g_L is equal to zero given that there is not much change in the actual land area for rice production. In other words, suppose the regulation of Vietnamese government banning conversion of rice land to other purposes is enforced efficiently, then the rate of change in the area of land used for rice production can be ignored.

Finally, we consider the growth rate of total factor productivity (g_A). This is complicated because it depends directly on the growth effects of trade liberalisation (see equation (8.19)). Suppose the market structure and price level in the goods and factor markets, as represented by $\delta\beta p(1 - C_0 m)$, changes significantly (as suggested by the available data for the period of 1981 to 1987) in the earliest years of a period of trade liberalisation and then became constant after five or seven years of this particular trade regime. Obviously we can not simply assume that the growth rate of total factor productivity is the same for 1981-87 and 1988-2002, but it is reasonable to assume that in the period from 1988 to 2002, A_1, (see equation (8.11)) the most important component for growth of total factor productivity, will no longer change because the value $\delta\beta p(1 - C_0 m)$ in A_1, will not be likely to change, having incurred all its change in earlier years, starting in 1981. On this supposition, the growth rate of $\delta\beta p(1 - C_0 m)$ may be assumed to equal zero for 1988-2002, and the growth rate of A_1 is zero too. If the annual growth rate of A in 1981-87 is about 3.8 per cent (see Table 7.2 for the whole of Vietnam), then the annual growth rate of total factor productivity must be less than that given the constancy of $\delta\beta p(1 - C_0 m)$ over this time. To deal with this problem, we consider the following alternative possibilities (reflecting varying degrees of optimism) for g_A.

- In the first and most pessimistic scenario, as a minimum benchmark (and one that still, as we shall see, shows the positive effects of trade liberalisation), assume that g_A equals zero per cent for the period from 1988-2002. Suppose too, as mentioned, that market structures and price levels do not change from 1987-2002 (i.e., that the component $\delta\beta p(1 - C_0 m)$ in equation (8.11) is constant since 1987), so that the component of the growth rate of total factor productivity directly due to liberalisation (A_1) is constant since 1987. Assume also that there are not significant changes in the other factors (apart from effects of trade) since 1987 so that the growth rate of the Solow residual is zero as well. Under both of these assumptions, overall total factor productivity does not change from 1987.[12]

- In the second case, as an optimistic possibility, assume that the annual growth rate of total factor productivity maintains the annual growth of rate 3.8 per cent (as experienced in 1981-87) until the steady state (see Table 7.6, for the whole of Vietnam). In other words, let g_A equal 3.8 per cent per year for the period 1988-2002.
- In the third case, as a compromise possibility, let g_A be equal to the arithmetic mean of the values in the first two cases above, or 1.9 per cent for 1988-2002.

Substituting into equation (8.13) the initial values of rice output in 1987 as 15102.6, 6075.2 and 9027.4 million tons of rice for Vietnam, the north and south respectively (Table 7.1), and the values $g_N = 0.6$, $g_L = 0$ and $g_{K1} = 3.1$ (Table 7.1 for the whole of Vietnam),[13] with the three different cases for the growth rate of total factor productivity (g_A, = 0 per cent ; g_A, = 3.8 per cent and g_A, = 1.9 per cent), the various alternative values for the long-run level of rice output in Vietnam, in the north, and in

[12]The main reservation about this approach is that it may be not be realistic to assume a zero growth rate of the Solow residual. In other words, the actual figure for the Solow residual in 1981-87 (Table 7.6) may not allow us simply to ignore the growth rate of this component in the growth of total factor productivity.

[13] It can be see that using the alternative measures of the annual growth rates for labour and current inputs in Tables 7.2 to 7.4 gives even higher steady state values for output and predicted annual growth rates for the period 1988-94. Using the measures in Table 7.1 (the relatively more pessimistic case) still gives strong conclusions regarding these effects.

the south (at the point of fifty years after 1980) are obtained and are summarised in Table 8.2.

According to Table 8.2, and under all three cases for g_A, trade liberalisation in this period of output contracts still provides positive effects on the steady-state level of rice output. The difference in the value of steady-state rice output between this period and the period of the communal system is 4.53, 19.25 and 11.0 million tons of rice for the first, second and third case of g_A respectively, for the whole of Vietnam. That difference is 1.82, 7.75 and 4.43 million tons of rice for the north and 2.70, 11.50 and 6.58 million tons of rice for the south. As such, these results provide a confirmation of the theoretical analysis: trade liberalisation results in increases in the steady-state level of agricultural (rice) output.

These results also allow us to compute the predicted annual growth rate of rice output in this period. Since we know the initial value of rice output (as the arithmetic average of rice output for the years 1976-80), the steady-state value of rice output, and the time-scale for the system to reach the vicinity of the steady state (all are collected in Table 8.3), the predicted annual growth rate of rice output is easily calculated and shown for various cases of g_A, for Vietnam, the north and the south (see Table 8.3).

(b) The steady-state value of rice output in the period of the opening up of markets

According to the result in Section 8.2, recall the timescale for long-run growth in this period is about fifteen years. Thus if the system starts in 1988-89, it will converge to a 'near' steady-state value in 2004, and the year 1994 is the fifth year in that process.

Following a similar approach to that employed in part (a) above, the parameters in equation (8.11) can be derived from actual values at year five of the process (or 1994) and the growth rate of the parameters from this year until the fifteenth year. Thus, the steady-state value for rice output is given by

$$Q = Y^{1994}\left(\frac{100+g_A}{100}\right)^{10}\left[\left(\frac{100+g_N}{100}\right)^{10}\right]^{\gamma_1}\left[\left(\frac{100+g_L}{100}\right)^{10}\right]^{\gamma_2}\left[\left(\frac{100+g_{K1}}{100}\right)^{10}\right]^{\gamma_3}\left(\frac{K_2^S}{K_2^{1994}}\right)^{\gamma_4} \quad (8.23)$$

where the annual growth rates for labour and current input are approximately 0.6 and 3.1 per cent respectively (see Table 7.1).

Following the same assumptions and arguments from above, we consider three possible values of the growth rate of total factor productivity from 1995 to 2004. The first case is that of a zero growth rate of total factor productivity. In the second case the annual growth rate of total factor productivity of 3.6 per cent in 1988-94 (see Table 7.6 for the whole of the country) is assumed to continue for 1995-2004. In the third or intermediate case, the growth rate of total factor productivity is 1.8 per cent. It is also assumed throughout that g_L is equal to zero.

The initial values of rice output in 1994 are 23528.3, 9100.0 and 14428.3 million tons of rice for the whole of Vietnam, the north, and south respectively (Table 7.1). Substituting those values and $g_N = 0.6$, $g_L = 0$ and $g_{K1} = 3.1$ per cent into equation (8.23), for the three possible values of g_A, we obtain three alternative values for the steady-state level of rice output for Vietnam, the north and south. These are summarised in Table 8.2. All three possibilities for the growth rate of total factor productivity confirm the positive and (here) dramatic effects of trade liberalisation on long-run rice output. Even in the most pessimistic case of a zero rate of growth of total factor productivity ($g_A = 0$), the difference in the long-run rice output between the period of the opening up of markets and the communal system is about 13.13, 4.84 and 8.29 million tons of rice and between the period of the opening up of markets and the period of output contracts is 8.60, 3.02 and 5.58 million tons of rice for Vietnam, the north, and the south respectively (see Table 8.2).

Again, following a similar approach to that above, we can compute the predicted annual growth rate of rice output for the different cases of g_A, for Vietnam, the north and the south (see Table 8.3). Obviously, and relative to a given case of the growth of g_A, the growth rate of rice output in this period is much higher than that in the period of output contracts with tightly controlled markets, and further trade liberalisation implies even stronger effects on the growth rate of rice output. For example even in the most pessimistic case with g_A equal to zero per cent, the annual growth rate of rice output in the period of opening up of markets is 4.3 , 4.0 and 4.5 compared with 1.8, 1.2 and 1.2 per cent in the period of output contracts for Vietnam, the north and the south respectively.

8.5 Concluding remarks

This chapter shows that the predictions of the theoretical model of Chapter 5 regarding the transitional paths and steady-state values for capital and rice production are fully consistent with the actual data and the empirical analysis. Each new stage of liberalisation results in a new and higher steady-state level of physical capital and rice output. Indeed, based upon a construction of the timescale for the system to reach the vicinity of the steady state, our results show that even with an assumed zero rate of growth in the 'Solow residual' component of total factor productivity that trade and market liberalisation *alone* may increase the production of rice output by an order of two times its initial value. It is also clear that the second stage of liberalisation has higher growth effects on the rice output than in the first stage implying that incentive effects and more open markets matter greatly.

Table 8.2 The long-run level for rice output in the different stages of trade liberalisation *(thousand tons)*

The steady-state rice output in the different stages of trade liberalisation		VIETNAM			The north			The south		
		Case 1 for growth of g_A	Case 2 for growth of g_A	Case 3 for growth of g_A	Case 1 for growth of g_A	Case 2 for growth of g_A	Case 3 for growth of g_A	Case 1 for growth of g_A	Case 2 for growth of g_A	Case 3 for growth of g_A
(0)	The communal system	15102.6	15102.6	15102.6	6075.2	6075.2	6075.2	9027.4	9027.4	9027.4
(I)	Output contracts	19633.4	34358.5	26112.4	7897.8	13821.2	10504.1	11735.6	20537.3	15608.3
(II)	The opening up of markets	28234.0	40092.3	33880.8	10920.0	15506.4	13104.0	17314.0	24585.9	20776.8
The difference of the steady-state rice output										
Between the period (I) and (0)		4530.8	19255.9	11009.8	1822.6	7746	4428.9	2708.2	11509.9	6580.9
Between the period (II) and (I)		8600.6	5733.8	7768.4	3022.2	1685.2	2599.9	5578.4	4048.6	5168.5
Between the period (II) and (0)		13131.4	24989.7	18778.2	4844.8	9431.2	7028.8	8286.6	15558.5	11749.4

Note: *The period (0), (I) and (II) represent for the period of the communal system, output contracts with tightly controlled markets and the opening up markets respectively.*

Table 8.3 **The predicted annual growth rate of rice output in the different stages of trade liberalisation** *(per cent)*

Period of liberalisation	VIETNAM			The north			The south		
	Case 1 for growth of g_A	Case 2 for growth of g_A	Case 3 for growth of g_A	Case 1 for growth of g_A	Case 2 for growth of g_A	Case 3 for growth of g_A	Case 1 for growth of g_A	Case 2 for growth of g_A	Case 3 for growth of g_A
The output contracts									
-Initial level of rice output *(thous tons)*	15102.6	15102.6	15102.6	6075.2	6075.2	6075.2	9027.4	9027.4	9027.4
-The long-run level of rice out put *(thous tons)*	19633.4	34358.5	26112.4	7897.8	13821.2	10504.1	11735.6	20537.3	15608.3
-Time scale for reaching the vicinity to steady state *(year)*	22	22	22	22	22	22	22	22	22
-Predicted annual growth rate of rice output *(per cent)*	1.8	3.7	2.5	1.2	3.8	2.5	1.2	3.7	2.5
The opening up of markets									
-Initial level of rice output *(thous tons)*	15102.6	15102.6	15102.6	6075.2	6075.2	6075.2	9027.4	9027.4	9027.4
-The long-run level of rice out put *(thous tons)*	28234.0	40092.3	33880.8	10920.0	15506.4	13104.0	17314.0	24585.9	20776.8
-Time scale for reaching the vicinity to steady state *(year)*	15	15	15	15	15	15	15	15	15
-Predicted annual growth rate of rice output *(per cent)*	4.3	7.0	5.6	4.0	6.5	5.3	4.5	6.9	5.7

Appendix 8A: LINEAR APPROXIMATION OF THE DYNAMIC MODEL

The system of simultaneous differential equations in consumption *(c)* and capital (k_2) that characterise the dynamic model is given by equations (5.25) and (5.29)

$$\dot{k}_2(t) = f(c(t), k_2(t)) = c(t)^{\frac{-\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}} B_4 k_2(t)^{\frac{z\alpha_4}{z-\alpha_1-\alpha_2}} - (\mu+n)k_2(t) - c(t) - \beta pd \tag{8A.1}$$

$$\dot{c}(t) = g(c(t), k_2(t)) = \frac{1}{\sigma}\left[c(t)^{\frac{-\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}+1} B_4\alpha_4 k_2(t)^{\frac{z\alpha_4}{z-\alpha_1-\alpha_2}-1}\right] - \frac{1}{\sigma}c(t)(\mu+n+\rho) \tag{8A.2}$$

where B_4 is given as in equation (5.22) or

$$B_4 = \delta^{\frac{\alpha_1+\alpha_2}{z-\alpha_1-\alpha_2}} B_3^{\frac{z}{z-\alpha_1-\alpha_2}} \alpha_1^{\frac{\alpha_1}{z-\alpha_1-\alpha_2}} \alpha_2^{\frac{\alpha_2}{z-\alpha_1-\alpha_2}}. \tag{8A.3}$$

Linearise around the steady-state value (c^*, k_2^*) to obtain

$$\begin{bmatrix} \dot{k}_2(t) \\ \dot{c}(t) \end{bmatrix} = \begin{bmatrix} f_{k_2(t)} & f_{c(t)} \\ g_{k_2(t)} & g_{c(t)} \end{bmatrix} \begin{bmatrix} k_2(t) - k_2^*(t) \\ c(t) - c^*(t) \end{bmatrix} \tag{8A.4}$$

where

$$f_{k_2(t)} = \frac{z\alpha_4}{z-\alpha_1-\alpha_2} c^{\frac{-\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}} B_4 k_2(t)^{\frac{z\alpha_4}{z-\alpha_1-\alpha_2}-1} - (\mu+n) \tag{8A.5}$$

$$f_{c(t)} = -\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2} c(t)^{\frac{-\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}-1} B_4 k_2(t)^{\frac{z\alpha_4}{z-\alpha_1-\alpha_2}} - 1 \tag{8A.6}$$

$$g_{k_2(t)} = \frac{1}{\sigma}\left(\frac{z\alpha_4}{z-\alpha_1-\alpha_2} - 1\right) c(t)^{\frac{-\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}+1} B_4\alpha_4 k_2(t)^{\frac{z\alpha_4}{z-\alpha_1-\alpha_2}-2} \tag{8A.7}$$

and

$$g_{c(t)} = \frac{1}{\sigma}\left[-\frac{\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2} + 1\right] c(t)^{\frac{-\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}} B_4\alpha_4 k_2(t)^{\frac{z\alpha_4}{z-\alpha_1-\alpha_2}-1} - \frac{1}{\sigma}(\mu+n+\rho). \tag{8A.8}$$

The values of $f_{k_2(t)}$, $f_{c(t)}$, $g_{k_2(t)}$ and $g_{c(t)}$ are evaluated at the steady state, where

$$c(t)^{\frac{-\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}} B_4 k_2(t)^{\frac{z\alpha_4}{z-\alpha_1-\alpha_2}} = (\mu+n)k_2(t) + c(t) \tag{8A.9}$$

and

$$\left[c(t)^{\frac{-\sigma(\alpha_1+\alpha_2)}{z-\alpha_1-\alpha_2}} B_4 \alpha_4 k_2(t)^{\frac{z\alpha_4}{z-\alpha_1-\alpha_2}-1} \right] = (\mu + n + \rho) \qquad (8A.10).$$

Substituting (8A.9) into (8A.5) and (8A.6), implies that $f_{k_2(t)}$ and $f_{c(t)}$ are given as

$$f_{k_2(t)} = \left[(\mu + n) + \frac{c^*(t)}{\dot{k}_2(t)} \right] \frac{z\alpha_4}{z - \alpha_1 - \alpha_2} - (\mu + n) \qquad (8A.11)$$

and

$$f_{c(t)} = -\frac{\sigma(\alpha_1 + \alpha_2)}{z - \alpha_1 - \alpha_2} \left[(\mu + n) \frac{\dot{k}_2(t)}{c^*(t)} + 1 \right] - 1 \cdot \qquad (8A.12).$$

Substituting (8A.10) into (8A.7) and (8A.8), gives $g_{k_2(t)}$ and $g_{c(t)}$ as

$$g_{k_2(t)} = \frac{1}{\sigma}\left(\frac{z\alpha_4}{z - \alpha_1 - \alpha_2} - 1 \right)(\mu + n + \rho)\frac{c^*(t)}{\dot{k}_2(t)} \qquad (8A.13)$$

and

$$g_{c(t)} = -\frac{\alpha_1 + \alpha_2}{z - \alpha_1 - \alpha_2}(\mu + n + \rho) \cdot \qquad (8A.14).$$

To compute the values of $f_{k_2(t)}$, $f_{c(t)}$, $g_{k_2(t)}$ and $g_{c(t)}$ for the rice industry in Vietnam, use the parameters as determined earlier (see Chapters 5, 6 and 7), where $z \approx 3$ and $\alpha_1 \approx 0.4$; $\alpha_2 \approx 0.3$; $\alpha_3 \approx 0.2$ and $\alpha_4 \approx 0.1$ (see Appendix 7A); for the annual growth rate of labour force ≈ 0.006 (see Table 7.1). Assume the value of the inverse of the constant intertemporal elasticity of substitution σ is 0.1 (as in Section 8.1); the depreciation rate for physical capital μ is 0.015[14], and the value of a constant subjective rate of time preference ρ is 0.01. The ratio $\frac{c^*}{\dot{k}_2}$ is determined approximately from equations (5.42) and (5.43), where

$$\frac{c^*}{\dot{k}_2} \approx \frac{\rho + (1 - \alpha_4)(\mu + n)}{\alpha_4} \approx 0.28 \qquad (8A.15).$$

[14]This value is slightly smaller than usual (cf. Barro and Sala-i-Martin (1995, p.81), due to the nature of the fertility rate of buffaloes and cattle, both an important source of the capital stock.

Substituting the given value of parameters above into equations (8A.11) through (8A.14), the value of the elements in the matrix $\begin{bmatrix} f_{k_2(t)} & f_{c(t)} \\ g_{k_2(t)} & g_{c(t)} \end{bmatrix}$ in (8A.4) is given as

$$\begin{bmatrix} f_{k_2(t)} & f_{c(t)} \\ g_{k_2(t)} & g_{c(t)} \end{bmatrix} = \begin{bmatrix} 0.02 & -1.03 \\ -0.07 & -0.01 \end{bmatrix} \tag{8A.16}$$

Substituting (8A.16) into (8A.4), the system of differential equations for physical capital *($k_2(t)$)* and consumption *c(t)*

$$\begin{bmatrix} \dot{k}_2(t) \\ \dot{c}(t) \end{bmatrix} = \begin{bmatrix} 0.02 & -1.03 \\ -0.07 & -0.01 \end{bmatrix} \begin{bmatrix} k_2(t) - k_2^* \\ c(t) - c^* \end{bmatrix} \tag{8A.17}$$

Continuing to substitute the value c^* as the value 0.28 of k_2^* (see (8A.15) into (8A.17)), we can rewrite (8A.17) in standard form

$$\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} \dot{k}_2(t) \\ \dot{c}(t) \end{bmatrix} + \begin{bmatrix} -0.02 & 1.03 \\ 0.07 & 0.01 \end{bmatrix} \begin{bmatrix} k_2(t) \\ c(t) \end{bmatrix} = \begin{bmatrix} 0.27k_2^* \\ 0.07k_2^* \end{bmatrix} \tag{8A.18}$$

where the steady-state values for capital in the stage of output contracts and the opening up of markets (k_2^*) are taken from Table 8.1.

To obtain the general solution, we adopt trial solutions of the form

$$k_2^C(t) = ae^{rt} \text{ and } c^C(t) = be^{rt}. \tag{8A.19}$$

Substituting (8A.19) in the underlying homogenous system for (8A.18), yields

$$\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} a \\ b \end{bmatrix} re^{rt} + \begin{bmatrix} -0.02 & 1.03 \\ 0.07 & 0.01 \end{bmatrix} \begin{bmatrix} a \\ b \end{bmatrix} e^{rt} = 0. \tag{8A.20}$$

This implies

$$\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} r + \begin{bmatrix} -0.02 & 1.03 \\ 0.07 & 0.01 \end{bmatrix} = 0 \quad \text{or } det \begin{bmatrix} r - 0.02 & 1.03 \\ 0.07 & r + 0.01 \end{bmatrix} = 0. \tag{8A.21}$$

The resulting characteristic equation in r is

$$r^2 - 0.01r - 0.07 = 0 \tag{8A.22}$$

with roots r_1 =-0.25 and r_2 =0.25.

Thus the general solution for capital takes the form

$$k_2^C(t) = a_1 e^{-0.25t} + a_2 e^{0.25t}. \tag{8A.23}$$

Following Barro and Sala-I-Martin (1995, p.88), a_2 must equal zero for the appropriate transversality condition to hold, leaving only the stable root. Thus, the general solution for capital is found to be

$$k_2^C(t) = a_1 e^{-0.25t} \tag{8A.24}$$

According to (8A.24), the speed of convergence of capital is found to be -0.25 for any stage of trade liberalisation.

For the particular solution, to (8A.18), we have

$$\begin{bmatrix} -0.02 & 1.03 \\ 0.07 & 0.01 \end{bmatrix} \begin{bmatrix} \bar{k}_2 \\ \bar{c} \end{bmatrix} = \begin{bmatrix} 0.27k_2^* \\ 0.07k_2^* \end{bmatrix} \tag{8A.25}$$

or

$$\begin{bmatrix} \bar{k} \\ \bar{c} \end{bmatrix} = \begin{bmatrix} -0.02 & 1.03 \\ 0.07 & 0.01 \end{bmatrix}^{-1} \begin{bmatrix} 0.27k_2^* \\ 0.07k_2^* \end{bmatrix} = \begin{bmatrix} 0.97k_2^* \\ 0.28k_2^* \end{bmatrix}. \tag{8A.26}$$

Thus, the time path of physical capital in a given stage of trade liberalisation is obtained from (8A.24) and (8A.26), or

$$k_2^t(t) = k_2^C + \bar{k}_2 = a_1 e^{-0.25t} + 0.97k_2^* \tag{8A.27}.$$

The values of $\bar{k}_2$ or (k_2^*) and a_1 in (8A.27) clearly depend on the values of the parameters in the different stages of trade liberalisation.

Chapter 9

CONCLUSION

In the last two decades significant economic reforms have taken place in what were once purely socialist economies. Most importantly, these economies have undergone a sweeping process of internal and external trade liberalisation by gradually moving towards a system of fully-functioning competitive markets. Along with this, there have been profound changes in institutional arrangements and, in particular, changes in property rights that allow for some form (in varying degrees) of private ownership and control. The results have been astounding. In Vietnam, rice production has increased dramatically and indeed, as we have shown, directly in line with the pace and progress of economic reform.

This dissertation has focused directly on the effects of this trade liberalisation. It provides a theoretical and empirical analysis which explains the increases in both rice output and its growth in terms of the incentive effects that result from changes in property rights and market structures. Private ownership and control of property and competitive pricing and market structures induce individuals to work harder and use land more efficiently.

To capture these effects of changes in both market structure and incentives we began first with a static model of the effects of trade liberalisation on agricultural output. There, effective labour and land are measured in terms of efficiency units which include the optimal choice of effort in both work and the exploitation of land, thus incorporating incentive effects, whereas changes in the definition of the profit function measure the relevant changes in policy and institutional structures across the various transitional periods that go with the gradual 'freeing up' of domestic and international markets. The form of the institutional production function and the resulting comparative statics effects clearly show that total factor productivity, the optimal choice of effort, and rice output increase directly with the extent of trade liberalisation.

Next, the static model is extended to allow for intertemporal effects. A dynamic optimal control problem for the representative farmer is developed in a way that accounts for changes in market structures and the specific effects of using land and labour more efficiently over time. Here, trade liberalisation results in both enhanced path and steady-state effects. The long-run values of output per capita and the capital-labour ratio, in particular, increase with each stage of economic reform, from the communal system, to output-contracts, to the period of the total 'freeing up' of domestic and international markets.

Finally, based on the theoretical models, an extensive empirical analysis of the various stages of trade liberalisation for the case of Vietnam is undertaken. Given estimated results for the share parameters of labour, land, current inputs, and capital in the rice production function we show that the growth in factor productivity that results from changes in market structure and incentive effects is the most important explanatory factor for the increase in rice production, and that each new stage of trade liberalisation results in new and higher steady-state values for rice output. The positive effects of trade liberalisation are also seen through an analysis of the predicted growth rates of rice output in the different stages of trade liberalisation, where that growth rate in the period of full-trade liberalisation is shown to be much higher than that in the period of partial-trade liberalisation. The miracle of Vietnam moving from the position of a large importer of rice and other foodstuffs (barely able to feed its own population), to the third largest exporter of rice in the world, all in the short space of just over a decade, is due not to any 'great leap forward' in technology or factor supplies but purely to economic reform. Competition, changes in market structures and property rights, along with the enhanced incentive effects that go with it, matter most.

Data Appendix

DATA SOURCES AND ADJUSTMENTS

This Data Appendix documents the various and extensive data sources used in this dissertation. It also briefly describes the specific adjustments that were made to the data for use in the empirical analysis in this work. It is divided into three sections, as follows.

Section DA.1 documents data sources and adjustments for the set of cross-sectional data in fifty-three provinces and cities of Vietnam. This data set, which includes output and inputs for rice production, is principally used for the regression of the share parameters of inputs in the rice production function in Chapter 6. The concepts and the derivations of the specific economic terms and data categories which are used in this dissertation are also presented in this section. Section DA.2 provides three time-series data sets (from 1976 to 1994) of output and inputs in rice production for the whole country, and the north and south of Vietnam separately. These data sets are used for the analysis of the effects of internal and external trade liberalisation (Chapter 7) and the dynamic transitional path and long-run growth of rice production (Chapter 8). Finally, Section DA.3 collects data sources and the derives the time-series data of the composite price between output and input, or $\beta p(1\text{-}C_0 m)$ as defined in Chapter 4 above. This time-series data (again) is also used for the analysis of the effects of internal and external trade liberalisation (Chapter 7) and the dynamic transitional path and long-run growth for rice production (Chapter 8). To obtain the time-series data for $\beta p(1\text{-}C_0m)$, this section computes separately the changes in the average output price (βp) and the average weighted cost share parameter (m) during the period 1976 to 1994.[1]

In a nutshell, the original data sources come mainly from the General Statistics Office of Vietnam (GSO) and related project investigations, studies and reports by Vietnamese organisations, such as the State Planning Committee (SPC); the Ministry of Agriculture and Food Processing Industry (MAFI); the Ministry of Water Resources (MWR); the State Department of Price (SDP), and international organisations such as the World Bank (WB) and the Food and Agriculture Organisation (FAO). Some other sources of data are based on the individual investigations, books, and research papers constructed and assembled by specialists on Vietnam.

Nevertheless, due to the often inadequate and conflicting data sources, as well as the lack of sufficient studies on rice production in Vietnam, many adjustments and constructions of the data are required. For data adjustments, the various assumptions and the technical coefficients from empirical studies in other developing countries are used. Since errors and shortcomings are unavoidable, various comments on data construction are also made and discussed in this Data Appendix.

DA.1 The cross-sectional data set of output and inputs for rice production in fifty-three provinces in Vietnam (1993)

Data sources for Vietnam are barely sufficient to construct a cross-sectional data set for

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[1]At the end of this Data Appendix, the Sub-Appendix describes and collect more details on the data which are used for all of the work and the calculations in the previous three sections.

rice production for fifty-three provinces and cities. Until now, the 'National Investigation of Rural Region (NIRR) in Vietnam' conducted in July 1994 by the Statistics Department of Agriculture, Forestry and Fishery (SDAFF)-General StatisticsOffice (GSO), (1995b) is the most accurate and detailed investigation about the rice industry for the all regions in Vietnam. Based on the NIRR, this section constructs the cross-sectional data set of the rice industry for 53 provinces and cities in 1993.

(a) Index of rice output

The data is referenced from the Statistical Yearbook (GSO, 1994) for the entire grain industry in terms of an index of the quantity of 'rice equivalent'. A rice equivalent output is chosen rather than rice output alone, because in the same rice fields farmers usually overlap production with other short term cereal crops, such as sweet potatoes and maize. Since there is clear (nutritional) substitution between rice and these grains (SDP, 1995a), the State's target usually emphasises output in terms of a rice equivalent rather than rice only, converting (for example) so many ton of sweet potatoes into a comparable measure of rice output. There are two main problems with this data: First, differences of rice quality are ignored and second, the data source does not adjust regionally for the influence of bad weather on rice output at a specific time.

(b) The labour force

Data for the labour force are available for agriculture as a whole but not for the rice or food grain industry separately. With the overlapping of crops in a given field in the food grain industry, farmers use their time for multiple activities, so, by necessity, the labour force for the food grain industry is assumed to simply represent the labour force for the rice industry. Based on the data of labour for agriculture as a whole, we can derive approximately the labour force for rice or food grain production. The rice labour force is indicated in Table DA.1, where it is obtained by multiplying the total labour force for agriculture (SDAFF, GSO, 1994) with a weighted ratio between the cultivated area of grain to the total area cultivated for agriculture as a whole (see Table DA.1). Further, we suppose that the process of trade liberalisation affects the structure of rural labour along a time path rather than cross sectionally at the one time (Ministry of Planning and Investment, MPI, National Economics University, NEU, 1995).[2]

(c) The sown area of rice

The data for rice as sown area is from the National Investigation of Rural Regions (NIRR) in Vietnam by the GSO in 1994 (see Table DA.1). Table DA.1 also collects some main data on land, such as total area, agricultural land, cultivated land, land for food grains and land for rice production for every province and city separately. The problem with this data is that (of course) it does not clearly reflect the quality of land, which is distinguished mainly by two standards: the quality of the soil and the amount of land area that is irrigated (Che T Nhu, 1996b).

In fact, the Vietnamese government divides the soil quality of land into seven levels and levies land tax depending on quality (UNDP-FAO, 1989). An investigation by the World Bank (WB, 1994b) distinguished the quality of soil into five levels in terms of cultivated area. Irrigation is more advanced in the Red River Delta than in the

[2] While over time the economic liberalisation has clearly impacted on the structure of labour (MPI, NEU, 1995), cross-sectionally agriculture remains the primary occupation of 84 per cent of all rural workers (WB, 1995).

Cuu Long River Delta (MWR, 1994 and WB, 1995). According to the World Bank (1995), the difference in output between no and 100 percent irrigation on a farm amounts to 645 kg/hectare of rice, everything else equal.[3]

(e) Total current input

Following Tang (1980, p.61) and Sicular (1985), total current input is obtained by a measure of the nutrition content of all fertiliser (organic and chemical), insecticide, and seeds that are used for rice production. The equation to determine total current input from fertiliser, insecticide and seeds with the weighted assigned ratios is given by

$$TCI = 0.764TF + 0.178SE + 0.052IN \qquad \text{(DA.1)}$$

where *TCI, TF, SE, IN* are total current input, total nutrition content of all fertiliser, seeds, and insecticide respectively. This equation is adjusted, following Sicular (1985), so that the data for feed for animal husbandry is ignored.

The total nutrition content of all fertiliser in equation (DA.1) is determined from the nutritional content of organic and chemical fertiliser separately. Here, the amount of organic fertiliser for the rice industry is derived from the total amount of organic fertiliser used for agriculture. Following Tang (1980, p.61), the organic fertiliser for agriculture is assumed to be supplied from two main sources: night soil and large animal manure (buffaloes, cattle and pigs), which is given by

$$NCOF = 0.11NS + 0.0087LA \qquad \text{(DA.2)}$$

[3]The adjusted data of land based on its quality may be constructed according to quality levels in every province (WB, 1994, Annex 1, p.3). As mentioned, the Vietnamese government bases the average yield per hectare for seven levels of land in order to levy an amount of tax on each different quality of land. In particular, the amount of tax per hectare is 700 kg, 560 kg, 420 kg, 350 kg and 280 kg of unhusked rice for classes 1, through 5 respectively (UNDP-FAO, 1989). However, there is no conversion ratio between the classes 2 to 4 and 5 to 1, so we skip this means of adjustment.

where *NCOF*, *NS* and *LA* is the nutrition content of organic fertiliser, the population adjusted night-soil and the standard number of large animals respectively.

The population-adjusted night-soil equals the rural population (GSO, 1995) multiplied by a rural utilisation rate (0.9). The standard number of large animals equals the sum of buffaloes, cattle and pigs (GSO, 1994), for which the weighted ratios are 1, 1 and 0.33 respectively. The large animal manure is defined as in Tang's formula (1980, p.62)

$$LA=(0.7)(7.7)NLA \tag{DA.3}$$

where *NLA* is the number of the large animals, and here, the rural utilisation rate is 0.7 rather than 0.9 as in Tang's formula because this type of free range buffalo and cattle is very common in Vietnam.

The organic fertiliser for rice production is obtained by multiplying the amount of organic fertiliser for agriculture with the weighted ratio between food grain area sown to the total sown area for cultivation. The chemical fertiliser data used for rice production is derived directly from the multiplication of the average amounts of chemical fertiliser used (1992) in the north 165.4 kg/ha and the south 193 kg/ha (the Survey of Rice Farmers, SRF, Table S.1, Sub-Appendix) and the rice area in every province (see Table DA.1). The data are also adjusted from the data on chemical fertiliser obtained from the SDAFF-GSO (1996).

The series data for insecticides are constructed by multiplying the average use of insecticide per hectare in the year 1992, or 5.8 kg and 7.6 kg in the north and south, respectively, (SRF, 1993, Table S.2, Sub-Appendix) and the total rice area (Table DA.1). The derived data are all quite consistent with the study done by the World Bank

(1994). The data for seeds are calculated from the average use of seeds per hectare in 1992, or 140 kg/ha and 240 kg/ha in the north and south respectively, (SRF,1995) multiplied by the total rice area (GSO,1995). The main data sources and the constructed data of total current inputs for rice production are presented in Table DA.2.

(e) Total capital inputs

Following a similar approach to that used by McMillan, Whalley and Zhu, (1989), we assume that the physical capital input can be represented by capacity of tractors. It is very popular in LDC's for capacity of tractors to be supplemented by draught animals, so that the total capital input for cultivation is generated by adding together the number of draft animals (GSO,1994) and the total horsepower of machinery as according to the NIRR (GSO,1995). It can be assumed that the tractor capacity used for annual cultivation is also applicable for the rice industry because tractor capacity can vary in the rural areas at the rush time for rice production, just as it is does for other crops.

The conversion from the number of draught animals to capacity of tractors is based on observations in Pakistan (Blomqvist, 1986, p.142) that a bullock-day (a pair of bullock working 8 hours) is approximately the same as a tractor-hour, with a typical tractor being between 15 and 25 horsepower. Here, in the Vietnamese case, I assume that one cattle or buffalo-day is equivalent to about 0.6 bullock-days[4] (or about 14 hours of work by one pair of cattle or buffalo is about 8 hours of work by one bullock), with a typical tractor being around 15 horsepower.

[4] For simplification, I assume that the draft capacity of one head of cattle is equivalent to that of one buffalo. That is why the converted ratio which I used for Vietnamese case is quite low.

The data sources for the capacity of tractors are available by the NIRR (1994). However, there is some adjustment of the data. First, I adjusted downward the capacity of tractors for the mining provinces or coffee areas (where little rice is grown) such as Lao cai, Tuyen Quang and Dac Lac provinces. That adjustment is based on the data on mechanical devices used for food grain plantations in the regions of Vietnam (Ministry of Agriculture and Food Processing Industry, MAFI, 1993). Second, data from the NIRR also shows that the capacity of tractors is not fully representative of the capital investment in (total and) other plants and machines such as rice mills, threshing machines, generators, pumps, lorries, transport ships, etc., all of which are very popular in the south but much less so in the north. In fact, in general, farmers in the south use more machines for rice production than in the north (Nguyen T Khiem, 1995 and MAFI, 1993). In this case, I adjusted the capacity of tractors in the south by adding the capacity of all other machines.[5]

Data sources and results for the total capacity of tractors for every province and city are shown in Table DA.3. Although the data are constructed from inadequate sources, using approximate determinations, assumptions and adjustments, and no account is taken of State and private investment such as investment in irrigation and infrastructure (not available), the constructed data for capital are again quite consistent with other assessments by the GSO, (1995a), the MAFI (1994) and Nguyen V Bich and Chu T Quang (1994).

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[5] It is more popular in the north for farmers to use buffalo, cattle or human work instead of machines as they are poorer than farmers in the south. Besides, the size of land in the north for households is smaller than that in the south and the labour in the north is cheaper and more is available.

Table DA.1 **Main data for labour force and land use for the rice industry (1993)**

No	Province or city	Total of land area	Land for agriculture	Sown area for cultivation	Sown area for the food grain industry	Sown area for the rice industry	Labour for agriculture	Labour for the food grain industry
		(thous ha)	*(thous ha)*	*(thous ha)*	*(thous ha)*	*(thous ha)*	*(thous pers)*	*(thous pers)*
1	Ha Giang	783.10	130.40	95.20	74.60	24.38	202.40	158.60
2	Tuyen Quang	580.10	71.00	77.40	60.40	26.28	221.30	172.69
3	Cao Bang	844.50	72.90	89.60	74.80	27.3	225.10	187.92
4	Lang Son	818.70	84.30	77.20	62.50	35.24	229.00	185.40
5	Lai Chau	1713.30	110.00	97.20	87.40	44.85	157.60	141.71
6	Lao Cai	805.00	80.80	72.70	60.30	24.61	177.20	146.98
7	Yen Bai	680.80	78.10	72.90	56.60	23.83	147.50	114.52
8	Bac Thai	650.30	74.80	126.80	102.60	56.63	341.20	276.08
9	Son La	1421.00	174.40	106.00	83.60	50.08	272.70	215.07
10	Hoa Binh	461.20	72.10	100.90	75.70	41.62	243.10	182.39
11	Quang Ninh	593.90	57.40	78.60	64.40	29.51	121.20	99.30
12	Vinh Phu	482.70	140.20	243.10	202.00	96.07	771.90	641.40
13	Ha Bac	461.50	146.70	284.00	241.30	118.55	921.20	782.70
14	Ha Noi	92.10	44.20	90.30	76.50	37.17	290.20	245.85
15	Hai Phong	150.40	68.10	114.20	101.50	50.65	356.00	316.41
16	Ha Tay	214.80	124.20	250.30	216.20	95.44	800.70	691.62
17	Hai Hung	255.00	158.70	325.70	286.10	131.06	892.30	783.81
18	Thai Binh	151.00	104.00	227.80	198.20	88.99	659.10	573.46
19	Nam Ha	249.20	158.20	297.80	264.40	128.72	762.80	677.25
20	Ninh Binh	138.70	63.90	106.20	90.40	46.25	197.90	168.46
21	Thanh Hoa	1116.80	243.10	393.90	332.40	148.62	896.40	756.44
22	Nghe An	1637.10	179.00	333.00	260.80	110.20	864.70	677.22
23	Ha Tinh	605.40	105.10	170.20	136.50	68.12	385.70	309.33
24	Quang Binh	798.40	59.20	79.50	64.20	33.21	233.90	188.89
25	Quang Tri	458.80	59.50	67.70	54.00	24.06	125.70	100.26
26	Thua Thien Hue	500.90	47.10	73.20	64.00	21.57	185.10	161.84

Table DA.1 Main data for labour force and land use for the rice industry (1993) *(continued)*

No	Province or city	Total of land area *(thous ha)*	Land for agriculture *(thous ha)*	Sown area for cultivation *(thous ha)*	Sown area for the food grain industry *(thous ha)*	Sown area for the rice industry *(thous ha)*	Labour for agriculture *(thous pers)*	Labour for the food grain industry *(thous pers)*
27	Quang Nam -DN	1198.50	113.30	195.60	165.60	64.49	461.50	390.72
28	Quang Ngai	517.70	86.00	143.30	114.40	41.40	374.40	298.89
29	Binh Dinh	607.60	97.90	178.00	138.70	53.28	368.10	286.83
30	Phu Yen	527.80	59.90	91.60	66.30	33.44	229.70	166.26
31	Khanh Hoa	525.10	52.50	77.00	53.30	23.54	187.90	130.07
32	Ninh Thuan	342.70	35.10	48.10	38.60	15.66	103.40	82.98
33	Binh Thuan	799.20	88.50	133.40	82.40	53.85	170.60	105.38
34	Gia Lai	1621.20	181.90	142.70	87.60	65.16	152.20	93.43
35	Kon Tum	993.40	107.70	37.60	29.30	19.29	54.50	42.47
36	Dac Lac	1980.00	180.10	230.30	104.90	65.08	259.40	118.15
37	Lam Dong	1017.30	103.00	113.40	54.10	22.35	231.90	110.63
38	Ho Chi Minh City	209.00	92.10	120.60	82.50	57.11	275.40	188.40
39	Song Be	951.90	287.50	187.60	77.20	32.57	296.60	122.06
40	Tay Ninh	403.10	208.00	200.40	117.00	107.36	252.50	147.42
41	Dong Nai	586.40	258.80	296.30	112.20	56.90	475.90	180.21
42	Baria-Vung Tau	196.50	90.90	95.30	41.70	16.63	144.10	63.05
43	Long An	433.80	237.10	352.80	319.00	178.89	489.20	442.33
44	Dong Thap	327.60	212.40	367.50	335.90	183.35	590.30	539.54
45	An Giang	342.40	241.80	420.90	375.30	215.52	684.00	609.90
46	Tien Giang	233.90	169.00	330.60	270.00	99.98	572.10	467.23
47	Ben Tre	224.70	152.60	173.40	105.30	59.52	538.50	327.01
48	Vinh Long	148.70	117.40	224.50	189.30	74.13	403.90	340.57
49	Tra Vinh	236.90	159.40	211.20	172.90	96.62	350.80	287.18
50	Can Tho	296.40	244.50	413.60	356.30	150.36	603.40	519.81
51	Soc Trang	319.10	241.10	282.70	247.40	182.98	407.00	356.18
52	Kien Giang	624.30	286.60	373.10	347.30	221.99	481.40	448.11
53	Minh Hai	769.00	535.90	385.40	320.80	264.21	604.10	502.84

***Table DA.2* The data set for constructing total current inputs for the rice industry (1993)**

No	Province or city	Population of agriculture	Night soil	Buffaloes	Cattle	Pigs	No of large animal equivalent	Large animal manure	Content organic fertiliser	Organic fertiliser for rice industry	Chemical fertiliser	Content all fertiliser	Insecticide	Seed	Total current inputs
		(thous pers)	*(thous tons)*	*(thous head)*	*(thous head)*	*(thous head)*	*(thous head)*	*(thous tons)*	*(thous tons)*	*(thous tons)*	*(thous tons)*	*(thous tons)*	*(thous tons)*	*(thous tons)*	*(thous tons)*
1	Ha Giang	453.20	362.56	102.90	34.60	177.70	190.81	1028.47	48.83	15.49	4.03	19.52	0.14	2.68	15.40
2	Tuyen Quang	508.70	406.96	115.80	13.30	203.40	190.12	1024.75	53.68	27.33	4.35	31.67	0.15	2.89	24.72
3	Cao Bang	525.30	420.24	140.60	99.70	272.90	322.17	1736.50	61.33	23.41	4.52	27.93	0.16	3.00	21.88
4	Lang Son	516.10	412.88	190.90	32.70	197.60	282.88	1524.72	58.68	34.28	5.83	40.11	0.20	3.88	31.34
5	Lai Chau	420.80	336.64	96.90	14.10	164.40	160.32	864.12	44.55	22.32	7.42	29.74	0.26	4.93	23.61
6	Lao Cai	419.00	335.20	85.40	7.60	177.10	146.13	787.64	43.72	19.55	4.07	23.62	0.14	2.71	18.53
7	Yen Bai	462.30	369.84	68.00	23.10	208.60	153.68	828.34	47.89	25.23	3.94	29.17	0.14	2.62	22.76
8	Bac Thai	806.90	645.52	178.90	18.50	344.50	300.75	1621.04	85.11	51.21	9.37	60.58	0.33	6.23	47.41
9	Son La	632.80	506.24	96.30	83.90	286.80	266.24	1435.03	68.17	29.20	8.28	37.48	0.29	5.51	29.63
10	Hoa Binh	566.50	453.20	92.20	30.00	220.90	188.47	1015.85	58.69	25.59	6.88	32.48	0.24	4.58	25.64
11	Quang Ninh	316.20	252.96	57.60	9.20	227.50	135.05	727.92	34.16	19.90	4.88	24.79	0.17	3.25	19.52
12	Vinh Phu	1897.90	1518.32	116.70	156.70	606.00	455.20	2453.53	188.36	111.89	15.89	127.78	0.56	10.57	99.53
13	Ha Bac	2028.50	1622.80	176.90	82.70	715.40	474.22	2556.05	200.75	132.46	19.61	152.07	0.69	13.04	118.54
14	Ha Noi	734.80	587.84	25.40	38.80	261.80	142.74	769.37	71.36	43.94	6.15	50.08	0.22	4.09	39.00
15	Hai Phong	942.50	754.00	30.80	4.00	339.90	136.77	737.19	89.35	73.39	8.38	81.77	0.29	5.57	63.48
16	Ha Tay	1944.00	1555.20	58.40	87.80	573.60	318.28	1715.53	186.00	123.73	15.79	139.51	0.55	10.50	108.48
17	Hai Hung	2246.20	1796.96	64.40	52.60	682.60	321.78	1734.39	212.75	156.51	21.68	178.19	0.76	14.42	138.74
18	Thai Binh	1521.70	1217.36	26.50	36.70	460.70	201.41	1085.60	143.35	106.04	14.72	120.76	0.52	9.79	94.03
19	Nam Ha	2139.30	1711.44	34.00	37.40	667.80	271.74	1464.68	201.00	157.13	21.29	178.42	0.75	14.16	138.87
20	Ninh Binh	671.60	537.28	28.40	24.00	199.90	112.37	605.67	64.37	46.49	7.65	54.14	0.27	5.09	42.28
21	Thanh Hoa	2676.70	2141.36	217.10	175.80	780.40	627.02	3379.64	264.95	164.93	24.58	189.51	0.86	16.35	147.74
22	Nghe An	2088.80	1671.04	232.30	220.70	663.70	652.11	3514.87	214.39	120.40	18.23	138.62	0.64	12.12	108.10
23	Ha Tinh	1031.30	825.04	84.20	138.80	326.40	320.92	1729.76	105.80	65.40	11.27	76.66	0.40	7.49	59.93
24	Quang Binh	533.00	426.40	27.20	115.30	241.00	214.80	1157.77	56.98	32.97	5.49	38.46	0.19	3.65	30.04
25	Quang Tri	356.10	284.88	30.90	62.00	155.50	139.55	752.17	37.88	23.39	3.98	27.37	0.14	2.65	21.39
26	Thua Thien Hue	520.40	416.32	35.40	20.40	189.90	112.77	607.83	51.08	34.13	3.57	37.69	0.13	2.37	29.23

Table DA.2 **The data set for constructing total current inputs for the rice industry (1993)** *(continued)*

No	Province or city	Population of agriculture *(thous pers)*	Night soil *(thous tons)*	Buffaloes *(thous head)*	Cattle *(thous head)*	Pigs *(thous head)*	No of large animal equivalent *(thous head)*	Large animal manure *(thous tons)*	Content organic fertiliser *(thous tons)*	Organic fertiliser for rice industry *(thous tons)*	Chemical fertiliser *(thous tons)*	Content all fertiliser *(thous tons)*	Insecticide *(thous tons)*	Seed *(thous tons)*	Total current inputs *(thous tons)*
27	Quang Nam -DN	1173.00	938.40	51.80	192.60	508.40	396.92	2139.40	121.84	76.86	12.44	89.31	0.49	15.48	71.01
28	Quang Ngai	919.60	735.68	47.00	166.10	354.30	319.39	1721.51	95.90	60.63	7.99	68.62	0.31	9.94	54.21
29	Binh Dinh	973.50	778.80	17.70	210.10	295.10	316.33	1705.02	100.50	69.90	10.28	80.18	0.40	12.79	63.56
30	Phu Yen	531.70	425.36	3.50	152.50	155.80	202.74	1092.77	56.30	35.65	6.45	42.10	0.25	8.03	33.61
31	Khanh Hoa	457.10	365.68	15.40	62.90	107.80	110.64	596.35	45.41	22.59	4.54	27.13	0.18	5.65	21.74
32	Ninh Thuan	292.80	234.24	12.90	68.00	59.60	98.78	532.42	30.40	19.34	3.02	22.36	0.12	3.76	17.76
33	Binh Thuan	542.40	433.92	19.70	83.10	120.40	138.92	748.78	54.25	24.60	10.39	34.99	0.41	12.92	29.06
34	Gia Lai	378.30	302.64	15.50	206.50	221.10	288.33	1554.10	46.81	19.06	12.57	31.63	0.50	15.64	26.98
35	Kon Tum	135.90	108.72	8.10	51.70	79.40	83.62	450.71	15.88	7.90	3.72	11.62	0.15	4.63	9.71
36	Dac Lac	799.00	639.20	20.70	120.30	308.10	233.43	1258.19	81.26	26.39	12.56	38.95	0.49	15.62	32.56
37	Lam Dong	516.70	413.36	21.90	40.50	129.70	101.31	546.06	50.22	15.50	4.31	19.81	0.17	5.36	16.10
38	Ho Chi Minh City	624.40	499.52	29.80	40.40	178.40	123.72	666.85	60.75	40.75	11.02	51.77	0.43	13.71	42.02
39	Song Be	668.80	535.04	31.10	47.90	137.10	120.13	647.50	64.49	22.03	6.28	28.32	0.25	7.82	23.04
40	Tay Ninh	588.80	471.04	51.70	50.10	87.90	128.17	690.84	57.82	30.85	20.72	51.56	0.82	25.77	44.02
41	Dong Nai	1112.90	890.32	18.00	42.20	219.00	125.90	678.60	103.84	22.18	10.98	33.16	0.43	13.66	27.79
42	Baria-Vung Tau	320.50	256.40	2.40	19.90	86.60	48.28	260.23	30.47	6.36	3.21	9.57	0.13	3.99	8.03
43	Long An	1062.40	849.92	34.20	18.80	174.90	105.47	568.48	98.44	87.58	34.52	122.10	1.36	42.93	101.00
44	Dong Thap	1294.80	1035.84	7.80	5.10	177.10	66.03	355.90	117.04	105.70	35.38	141.08	1.39	44.00	115.69
45	An Giang	1527.60	1222.08	5.50	38.20	188.40	100.22	540.19	139.13	121.68	41.59	163.26	1.64	51.72	134.02
46	Tien Giang	1309.70	1047.76	7.20	8.00	380.50	129.35	697.20	121.32	97.50	19.29	116.79	0.76	23.99	93.54
47	Ben Tre	1054.60	843.68	17.00	35.10	227.00	120.20	v47.88	98.44	57.79	11.48	69.28	0.45	14.28	55.49
48	Vinh Long	784.70	627.76	9.00	10.50	176.70	72.51	390.83	72.45	60.00	14.30	74.30	0.56	17.79	59.96
49	Tra Vinh	744.90	595.92	19.30	26.60	163.70	95.01	512.10	70.01	55.12	18.64	73.77	0.73	23.19	60.52
50	Can Tho	1388.30	1110.64	6.90	1.20	218.70	73.71	397.30	125.63	107.46	29.01	136.48	1.14	36.09	110.75
51	Soc Trang	1042.70	834.16	22.10	5.10	172.30	78.89	425.22	95.46	82.66	35.31	117.97	1.39	43.92	98.02
52	Kien Giang	1031.60	825.28	23.80	9.10	243.30	105.89	570.75	95.75	88.10	42.84	130.93	1.69	53.28	109.60
53	Minh Hai	1385.00	1108.00	26.70	0.10	356.70	133.81	721.24	128.15	105.61	50.98	156.59	2.01	63.41	131.03

Table DA.3 **The data set for constructing capital input for the rice industry (1993)**

	Province or city	Draft animals		Total horse-power of draft animal	Capacity of large tractors	Capacity of small tractor	Total capacity of tractors
		Buffaloes	Cattle				
		(thous heads)	*(thous heads)*	*(thous)*	*(horsepower)*	*(horsepower)*	*(ten thous horsepower)*
1	Ha Giang	70.69	17.30	47.14	1064.1	216.2	4.84
2	Tuyen Quang	79.55	6.65	46.18	2962.7	2048.3	4.67
3	Cao bang	96.59	49.85	78.45	179.0	1320.0	8.00
4	Lang son	131.15	16.35	79.02	752.3	7470.1	7.98
5	Lai Chau	66.57	7.05	39.44	540.2	1981.3	4.20
6	Lao Cai	58.67	3.80	33.47	19324.2	533.5	3.55
7	Yen Bai	46.72	11.55	31.21	1222.2	433.4	3.29
8	Bac Thai	122.90	9.25	70.80	17729.6	4688.4	7.30
9	Son La	66.16	41.95	57.92	17116.2	2245.3	5.99
10	Hoa Binh	63.34	15.00	41.97	1948.0	1719.0	4.56
11	Quang Ninh	39.57	4.60	23.66	2555.0	6819.9	3.30
12	Vinh Phu	80.17	78.35	84.92	311.5	498.6	8.57
13	Ha Bac	121.53	41.35	87.26	14333.2	22041.6	9.03
14	Ha Noi	17.45	19.40	19.74	7718.0	17042.2	4.45
15	Hai Phong	21.16	2.00	12.41	12261.2	16906.4	1.54
16	Ha Tay	40.12	43.90	45.01	6872.8	31920.2	4.90
17	Hai Hung	44.24	26.30	37.79	12232.6	31959.5	4.18
18	Thai Binh	18.21	18.35	19.58	5249.0	9759.3	3.46
19	Nam ha	23.36	18.70	22.53	11401.9	22565.6	2.55
20	Ninh Binh	19.51	12.00	16.88	3271.0	11987.1	3.21
21	Thanh Hoa	149.15	87.90	126.99	4958.0	10659.5	14.26
22	Nghe An	159.59	110.35	144.61	8355.4	5202.2	15.82
23	Ha Tinh	57.85	69.40	68.17	14010.5	3533.1	8.57
24	Quang Binh	18.69	57.65	40.89	3210.6	2589.1	4.67
25	Quang Tri	21.23	31.00	27.98	10828.7	2932.9	4.17
26	Thua Thien Hue	24.32	10.20	18.49	3241.0	6730.0	2.85
27	Quang Nam DN	35.59	96.30	70.65	4589.8	4136.4	9.07
28	Quang Ngai	32.29	83.05	61.79	3516.8	2959.5	7.67
29	Binh Dinh	12.16	105.05	62.79	5566.2	17031.5	8.58
30	Phu Yen	2.40	76.25	42.14	4937.1	5072.3	6.52
31	Khanh Hoa	10.58	31.45	22.52	7681.4	5699.2	5.33
32	Ninh Thuan	8.86	34.00	22.96	18886.1	1423.1	6.97
33	Binh Thuan	13.53	41.55	29.51	34172.4	3453.1	11.60
34	Gia Lai	10.65	103.25	61.02	15935.0	3365.0	10.54
35	Kon Tum	5.56	25.85	16.83	1737.0	626.4	2.23
36	Dac Lac	14.22	60.15	39.84	85863.0	170835.0	6.74
37	Lam Dong	15.05	20.25	18.91	22238.0	14518.8	10.34
38	Ho Chi Minh City	20.47	20.20	21.79	9272.0	9292.6	6.45
39	Song Be	21.37	23.95	24.28	63218.6	7404.4	18.67
40	Tay Ninh	35.52	25.05	32.45	46840.3	8699.0	16.02
41	Dong Nai	12.37	21.10	17.93	92444.4	42835.1	8.69
42	Baria-Vung Tau	1.65	9.95	6.21	29065.5	10590.4	9.74
43	Long an	23.50	9.40	17.62	82434.2	20526.8	25.44
44	Dong Thap	5.36	2.55	4.24	106476.7	47473.3	35.83
45	An Giang	3.78	19.10	12.26	138151.5	27715.6	39.38
46	Tien Giang	4.95	4.00	4.79	33949.7	24695.0	13.97
47	Ben Tre	11.68	17.55	15.66	13319.3	12908.0	7.6
48	Vinh Long	6.18	5.25	6.12	21008.2	32094.6	12.83
49	Tra Vinh	13.26	13.30	14.23	12725.5	14972.0	7.79
50	Can Tho	4.74	0.60	2.86	83402.8	27890.0	25.88
51	Soc Trang	15.18	2.55	9.50	58627.7	18046.8	18.59
52	Kien Giang	16.35	4.55	11.20	81907.7	9973.4	22.25
53	Minh Hai	18.34	0.05	9.85	46012.3	18647.3	15.86

DA.2 Time-series data set for rice production 1976-94

This data set is used for the analysis of the effects of internal and external trade liberalisation (Chapter 7) and the dynamic transitional path and long-run growth for rice production (Chapter 8). The duration of time-series data is from the year of unification or 1976 to 1994. Thus, this length of time encompasses all the stages of internal and external trade liberalisation. The concepts of rice output, labour, current inputs and physical capital were defined as in Section DA.1. However, some more adjustments for constructing the time-series data are still needed.

(a) Index of rice output

The time-series of rice output for Vietnam, the north and south (separately) are provided by the SDAFF and the MAFI (1991) for the period from 1976-1990, by the SDAFF (1995a) for the period 1990-93 and by the GSO (1995) for 1994, (see Table 7.1 in Chapter 7).

(b) The labour force

The time-series data of total man-days work used in rice production for Vietnam, the north and south respectively is indicated in Table DA.4. The data are obtained by multiplying average man-days work per hectare with the rice cultivated area in 1976-94, (Table DA.5) and dividing by 300 days (where 300 man-days work equals one standard labour unit in one year).

Here the total man-days worked for rice production is used directly as a labour index since the data of structural changes in the agricultural labour during the process of trade liberalisation are not available.[6] Therefore, the approach to construct data using labour for agriculture alone (see Section DA.1) can induce cumulative errors over time.[7]

The average man-days worked per hectare for rice production in the RRD and CRD does not seem to change over time (SRF, various years).[8] In fact, average man-days worked per hectare depends mainly on natural conditions rather than social-economic influences.[9] Since the rice cultivated area has increased, so has the rice labour force. Here, the average man-days worked per cultivated hectare is computed from the average man-days work per hectare in wet and dry seasons, which is 245.4 and 61.5 for the north and south respectively (SRF, various years).[10] The total man-days worked for Vietnam is the sum of that for the north and south.

Time-series data of labour force for the rice industry in Vietnam, the north and south are presented in Table DA.4.

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[6] Hence, the approach in Section DA.1 is not suitable to construct the time-series data as mentioned above.

[7] Evidently, economic liberalisation has impacted on the labour structure and diversified farmer activities over time, and non-rice industries such as animal husbandry, small scale and service industries provide more secondary (or 'moonlighting') occupations as well as income for farmers (GSO, 1995a, the Department of General Statistics (DGS) and the DAFF-GSO (1996), Nguyen V Tuan (1995) and Tran D Hien, (1995). A high rate of growth for the labour force in agriculture does not mean a high or same growth rate of labour for rice production. While the growth rate of the labour force in rural areas is about the rate of population growth generally (2 per cent per annum (GSO, 1996), the growth of the labour force in rice production depends on the growth in rice production itself.

[8] The data in the north under cooperatives (GSO, 1975) compared to the time of the survey by the SRF (1995), shows the number of man-days worked per rice per crop hectare has even decreased during the period of reform. This case can be explained by errors in the working point system in the communal system, such as farmers shirking and magnifying the working time. After reform, farmers had incentives to work more productively and possibly use more equipment and at a higher rate of capacity utilisation.

[9] For example, the big difference of man days work per hectare between the north and the south is caused by different natural conditions (such as natural drainage and the resulting time needed to prepare the land for seed) in those regions.

[10] The SRF for 135 farm households in the RRD and 66 farm households in the CRD for 4 consecutive years (1989-92).

(c) The sown area of rice

The time-series of rice area sown for Vietnam, the north and south are provided by the General Department of Land Management, the SDAFF and the MAFI (1991), the SDAFF (1994), the SDAFF (1995b) and the GSO (1995) (see Table DA.6). Because the data are not adequate in some years (especially 1976-77 and 1980-84), the data are estimated from the annual average rate of decrease in sown area in those periods. Since the data gathering of the NIRR was conducted in July 1994, it is assumed to represent actual levels in both 1993 and 1994.

Data sources of annual cultivated area, food cultivated area and rice cultivated area come from the SDAFF and the MAFI (1991) for 1976-90, from the SDAFF (1994) for 1990-93 and the GSO (1995) for 1994, (Table DA.6). The data will be used to construct other time-series data.

(d) Total current input

Following a similar approach to that in Section DA.1, the construction for total current input includes the nutrition content of all fertiliser (organic and chemical), insecticide and seeds (Tang, 1980; and Sicular, 1985). Tables DA.7, DA.8 and DA.9 collect the data sources, which are used to construct total current input for the time-series data 1976-94 for Vietnam and the north and south respectively.

The construction of data for organic fertiliser is supplied from two main sources, the night soil and large animal manure, so it requires the time-series data of rural population and large animals (which includes buffaloes, cattle and pigs) from 1976-94. The time-series data of rural population and large animals come from the SDAFF and the MAFI (1992) for 1976-90, the SDAFF (1995a) for 1990-93, and the GSO (1995) for 1994.

The time-series data of chemical fertiliser, insecticide and seeds for Vietnam is provided by the SDAFF (1996). The construction of time-series of chemical fertiliser, insecticides and seeds for the north and south comes from the average ratio of fertiliser, insecticide and seeds used per hectare between the north and south (see Table S.1 and S.2, Sub-Appendix) and the cultivated area in every year (SDAFF, GSO, various years).

The main data sources and the constructed data of total current inputs for rice production in Vietnam, the north and south are presented in Tables DA.6, DA.7 and DA.8.

(e) Total capital inputs

The index of total capital inputs is defined as in Section DA.1 so it is generated by adding the number of draught animals (buffaloes and cattle) and the capacity of tractors. Data sources for the number of draft animals are fully provided by the SDAFF and the MAFI (1992) for the period from 1976-1990, the SDAFF (1995a) for the period 1990-93, and the GSO (1995) for 1994, (see Table DA.9). The formula for conversion from the number of draught animals to the capacity of tractors is defined as in Section DA.1.

However, the data sources for the capacity of tractors, especially for the north and south separately in 1976-94 are poor and not complete, except for the full data sources for the capacity of tractors by the NIRR for 1993 or 1994 (SDAFF, 1995b), so various adjustments are required.

The capacity of tractors for Vietnam is constructed from a series of publications by the SDAFF (GSO) ranging from 1991 to 1996.[11] The data are also complemented by the data from the GSO (1995). The data sources for constructing the capacity of tractors for the north and south (1993 and 1994) are based on the NIRR's figures (1994). In other years, there are no available data sources for the capacity of tractors in the north and south separately. Based on the rates of mechanisation for land preparation in the north and south, the capacity of tractors for the north and south are derived from the total capacity of tractors for the whole country.[12] In general, the percentages for mechanisation in the south increase faster and are much higher than in the north (Nguyen V Bich and Chu T Quang, 1994, MAFI, 1991, UNDP-FAO, Nguyen T Khiem, 1995 and SDAFF, 1995b)[13]. The main data sources and the derived data for capital (in terms of the capacity of tractors) for Vietnam, the north and south are presented in Table DA.9.

[11] The calculation for the capacity of large and small tractors is based on a similar evaluation to that used in the NIRR (DAFF, 1995b). For some years only the total number of tractors is available rather than number of large and small tractors separately, while for some other years there data are provided for 'standard tractors'. Based on previous years, I converted all of these data to that of standard tractors (15 horsepower) for use in other calculations.

[12] Those data are available from the MAFI (1991), in which the percentage of land preparation by machines is about 50 per cent in the CRD and 20.2 per cent in the RRD (for 1986-90). The evaluation and comparison of the rate of mechanisation between the north and south also were analysed by the VIE 88/033, (1989), Nguyen V Bich and Chu T Quang (1994) and Nguyen T Khiem (1995).

[13] Based on those sources, I estimated that the percentage of tractor capacity from machines in the south at 50 per cent, 60 per cent and 70 per cent for the total tractor capacity in Vietnam for 1976-80, 1981-88 and 1989-92 respectively.

Table DA.4 **Time series of the labour force for the rice industry in Vietnam as a whole, the north and the south taken separately (1976-94)**

Year	VIETNAM		THE NORTH		THE SOUTH	
	Total labour in agriculture *(thous persons)*	Total man-days worked *(thous standard labour*	Total labour in agriculture *(thous persons)*	Total man-days worked *(thous standard labour*	Total labour in agriculture *(thous persons)*	Total man-days worked *(thous standard labour*
1976	12596.4	764.1	6621.6	584.9	5974.8	179.2
1977	12977.4	764.2	6852.3	571.0	6125.1	193.2
1978	13103.8	782.1	6854.7	595.3	6249.1	186.8
1979	13250.8	786.0	6601.9	598.7	6648.9	187.3
1980	13885.0	768.6	6838.3	566.0	7046.7	202.6
1981	14243.0	803.8	6942.9	608.8	7300.1	195.0
1982	14601.4	810.1	7141.0	612.3	7460.4	197.8
1983	15029.2	800.5	7298.4	607.7	7730.8	192.8
1984	15627.7	803.4	7817.2	606.3	7810.5	197.1
1985	15766.0	810.8	7659.3	613.9	8106.7	196.9
1986	16135.5	798.9	7828.4	599.2	8307.1	199.7
1987	16668.8	794.3	8018.7	601.3	8650.1	193.0
1988	17047.9	805.5	8227.6	604.9	8820.3	200.6
1989	17373.1	818.9	8672.7	608.9	8700.4	210.0
1990	17723.9	827.4	8929.4	609.5	8794.5	218.0
1991	18458.5	832.5	9417.8	615.8	9040.7	216.7
1992	19538.8	862.1	9955.1	618.9	9583.7	243.1
1993	20482.9	853.1	10682.7	614.2	9800.2	238.9
1994	21699.1	866.7	15724.3	618.3	5974.8	248.5

Table DA.5 Land use in agriculture in Vietnam as a whole, the north and south separately (1976-94) *(thous hectare)*

Year	VIET NAM				THE NORTH				THE SOUTH			
	Annual cultivated area	Food cultivated area	Rice cultivated area	Sown area of rice	Annual cultivated area	Food cultivated area	Rice cultivated area	Sown area of rice	Annual cultivated area	Food cultivated area	Rice cultivated area	Sown area of rice
1	2	3	4	5	6	7	8	9	10	11	12	13
1976	6746.1	6192.2	5297.3	4710	3267	2931.7	2383.6	1672	3542.7	3249.5	2909.6	3038
1977	7243.2	6640.5	5468.7	4710	3463.6	3007.6	2326.9	1672	3714.4	3478.5	3034.3	3038
1978	7411.3	6780.1	5462.5	4664	3578.2	3236.4	2425.9	1666	3762.6	3492.8	3010.2	2998
1979	7545.7	6921.6	5485.2	4618	3571.4	3237.0	2439.7	1661	3886.6	3626.2	3011.4	2957
1980	7772.8	7049.3	5600.2	4572	3562.4	3195.5	2306.5	1656	4114.4	3777.4	3236.2	2916
1981	7769.0	6984.2	5651.9	4526	3347.6	3357.9	2480.7	1651	4021.9	3626.3	3171.2	2876
1982	7769.0	6968.1	5711.4	4481	3731	3301.0	2495.2	1645	4087.7	3667.1	3216.2	2835
1983	7671.8	6775.2	5611.0	4435	3626.6	3202.2	2476.5	1640	4045.2	3573.0	3134.5	2795
1984	7816.3	6817.3	5675.0	4389	3634.2	3162.1	2470.6	1635	4182.1	3655.2	3204.4	2754
1985	7840.3	6833.6	5703.9	4297	3661.3	3187.5	2501.5	1630	4179.0	3646.1	3202.4	2667
1986	7846.3	6812.3	5688.6	4250	3623.2	3145.7	2441.9	1651	4223.1	3666.6	3246.7	2599
1987	7789.0	6709.9	5588.5	4243	3688.6	3170.0	2450.4	1639	4100.4	3539.9	3138.1	2604
1988	7999.4	6967.8	5726.4	4109	3783.4	3302.7	2464.8	1633	4216.0	3665.1	3261.6	2491
1989	8071.3	7089.6	5895.8	4108	3757.9	3311.9	2481.2	1628	4313.4	3777.1	3414.6	2490
1990	8101.5	7110.9	6027.7	4108	3680.1	3223.8	2483.5	1618	4421.4	3387.1	3544.2	2490
1991	8475.1	7448.0	6032.7	4101	3657.1	3301.0	2509.5	1618	4818.0	4147.0	3793.2	2531
1992	8755.2	7707.4	6475.4	4100	3745.3	3397.8	2522.1	1570	5010.0	4309.6	3953.3	2517
1993	8894.0	7796.7	6386.8	4039	3841.3	3391.4	2519.4	1583	5052.7	4405.3	4040.0	2456
1994	8904.0	7809.0	6598.6	4039	na	3337.5	2506.1	1583	na	4471.5	4091.7	2456

Table DA.6 **The time-series data for constructing total current inputs for Vietnam (1976-94)**

Year	Population of agricul-ture area	Night soil	Buffaloes	Cattle	Pigs	Number of large animal equivalent	Large animal manure	Nutritional contents for organic fertiliser	Nutritional contents for organic fertiliser for paddy	Chemical fertiliser	Total nutritional fertiliser	Insecti-cide	Seed	Total current input
	(thous persons)	*(thous tons)*	*(thous head)*	*(thous head)*	*(thous head)*	*(thous head)*	*(thous tons)*	*(thous tons)*	*(thous tons)*	*(thous tons)*	*(thous tons)*	*(thous tons)*	*(thous tons)*	*(thous tons)*
1976	33723.0	23606.1	2256.5	1595.2	8958.1	6539.1	35245.91	2903.3	2279.8	369	2648.8	18.0	635.00	2137.6
1977	34365.0	24055.5	2289.7	1655.7	8739.2	6567.2	35396.99	2954.1	2230.3	403	2633.3	18.0	656.00	2129.6
1978	35422.7	24795.89	2327.7	1646.0	8838.9	6625.4	35710.74	3038.2	2239.3	469	2708.3	18.0	655.00	2186.7
1979	36092.2	25264.54	2293.0	1628.1	9348.0	6725.5	36250.45	3094.5	2249.5	381	2630.5	18.0	658.00	2127.7
1980	37435.3	26204.71	2313.0	1664.0	10001.2	6977.4	37607.97	3209.7	2312.6	182	2494.6	18.0	672.00	2026.4
1981	38254.3	26778.01	2380.3	1771.7	10493.4	7300.0	39347.11	3287.9	2391.9	219	2610.9	18.0	734.00	2126.3
1982	38837.7	27186.39	2445.1	1944.4	10784.9	7625.0	41098.59	3348.1	2461.3	262	2723.3	18.0	685.00	2203.5
1983	39686.6	27780.62	2500.2	2173.5	11201.9	8034.3	43304.72	3432.6	2510.5	376	2886.5	18.0	729.00	2336.0
1984	40414.5	28290.15	2549.2	2418.0	11759.9	8495.2	45788.97	3510.3	2548.6	375	2923.6	18.0	737.00	2365.8
1985	41243.8	28870.66	2590.2	2597.6	11807.5	8730.1	47054.97	3585.2	2608.2	386	2994.2	15.2	770.00	2425.4
1986	41876.6	29313.62	2657.6	2783.5	11795.9	8979.9	48401.50	3645.6	2643.1	524	3167.1	11.5	768.00	2556.9
1987	42774.7	29942.29	2752.7	2979.1	12050.8	9347.0	50380.55	3732.0	2677.6	421	3098.6	12.8	838.00	2517.2
1988	43662.9	30564.03	2806.8	3126.6	11642.6	9426.2	50807.11	3804.1	2723.2	589	3312.2	13.9	910.00	2693.2
1989	44629.5	31240.65	2871.3	3201.7	12217.3	9738.2	52488.84	3893.1	2843.8	542	3385.8	22.3	1002.00	2766.3
1990	45420.8	31794.56	2854.1	3120.8	12260.5	9653.1	52029.94	3950.1	2938.9	544	3482.9	22.5	1024.00	2844.4
1991	46734.0	32713.8	2858.8	3135.6	12194.3	9652.7	52028.00	4051.2	2883.7	743	3626.7	22.6	1071.00	2962.6
1992	48183.2	33728.24	2886.5	3201.8	13891.7	10255.8	55278.82	4191.0	3099.7	902	4001.7	23.0	1100.00	3254.3
1993	49474.5	34632.15	2960.8	3265.1	14873.9	10688.1	57608.70	4310.7	3095.5	1091	4186.5	23.3	1150.00	3404.4
1994	50566.2	35396.37	2960.8	3400.3	15925.5	11138.7	77191.46	4565.2	3363.1	1321	4684.1	23.5	1183.00	3790.4

Table DA.7 **The time-series data for constructing the total current inputs for the north (1976-94)**

Year	Population of agriculture *(thous persons)*	Night soil *(thous tons)*	Buffaloes *(thous head)*	Cattle *(thous head)*	Pigs *(thous head)*	Number of large animal equivalent *(thous head)*	Large animal manure *(thous tons)*	Nutritional contents of organic fertiliser *(thous tons)*	Nutritional contents of organic fertiliser for paddy *(thous tons)*	Chemical fertiliser *(thous tons)*	Total nutrition fertiliser *(thous tons)*	Insecti-cide *(thous tons)*	Seed *(thous tons)*	Total current input *(thous tons)*
1976	19014.5	13310.2	1844.4	680.8	6923.7	4602.3	24806.5	1679.93	1275.0	148.1	1423.1	6.4	301.5	1141.3
1977	19484.2	13638.9	1844.6	705.7	6148.3	4394.8	23687.9	1706.37	1211.1	155.4	1366.5	6.2	304.2	1098.5
1978	19555.8	13689.1	1867.4	714.9	6332.1	4481.9	24157.6	1715.97	1181.5	186.4	1367.8	6.3	334.5	1104.9
1979	19377.3	13564.1	1827.8	716.5	6642.9	4537.2	24455.3	1704.81	1172.7	151.9	1324.6	6.4	298.1	1065.4
1980	19712.6	13798.8	1813.7	720.9	6738.8	4556.2	24558.1	1731.53	1149.9	67.0	1216.9	5.9	282.7	980.4
1981	20050.8	14035.6	1852.3	746.9	6840.9	4651.5	25071.4	1762.03	1188.8	85.5	1274.3	6.2	344.3	1035.2
1982	20460.8	14322.6	1879.0	678.9	7021.9	4664.5	25141.5	1794.21	1238.8	101.7	1340.5	6.2	314.0	1080.4
1983	20934.1	14653.9	1898.3	905.8	7206.5	4966.1	26767.0	1844.80	1280.2	147.6	1427.8	6.3	319.7	1148.1
1984	21350.7	14945.5	1916.1	1009.0	7496.0	5173.9	27887.3	1886.62	1304.6	145.1	1449.6	6.2	309.5	1162.9
1985	21794.5	15256.2	1935.2	1093.3	7404.8	5249.9	28297.2	1924.36	1335.6	150.5	1486.1	7.0	321.2	1192.9
1986	22228.7	15560.1	1986.3	1180.1	7480.4	5410.5	29162.7	1965.33	1351.3	199.6	1550.9	5.3	321.2	1242.3
1987	22700.9	15890.6	2061.1	1278.8	7668.3	5640.4	30401.7	2012.46	1361.7	164.1	1525.8	5.9	363.6	1230.7
1988	23170.2	16219.1	2103.9	1371.6	7487.2	5721.7	30839.7	2052.41	1368.0	225.0	1593.1	6.4	388.9	1286.7
1989	23919.1	16743.4	2173.6	1452.4	7813.9	5970.2	32179.2	2121.73	1441.5	202.1	1643.6	6.4	417.0	1330.3
1990	24554.9	17188.4	2210.7	1458.3	8018.6	6074.6	32742.0	2175.58	1516.5	198.2	1714.7	6.4	402.6	1382.1
1991	25295.6	17706.9	2248.9	1967.8	7926.2	6594.6	35544.7	2257.00	1471.1	260.9	1732.1	6.4	381.6	1391.6
1992	26137.9	18296.5	2322.9	1529.4	8571.6	6423.8	34624.2	2313.85	1618.4	309.4	1927.8	6.6	440.7	1551.6
1993	26861.6	18803.1	2414.1	1552.5	9345.6	6770.3	36491.8	2385.82	1615.9	376.6	1992.5	6.7	486.9	1609.3
1994	27454.3	19218.0	2414.1	1646.5	10180.9	7114.9	55502.9	2596.86	1906.5	446.3	2352.8	6.7	446.3	1877.3

Table DA.8 **The time-series data for constructing the total current inputs for the south (1976-94)**

Year	Population in agriculture	Night soil	Buffaloes	Cattle	Pigs	Number of larger animal equivalent	Large animal manure	Nutritional contents of organic fertiliser	Nutritional contents of organic fertiliser for paddy	Chemical fertiliser	Total nutritional fertiliser	Insecti-cide	Seed	Total current input
	(thous persons)	*(thous tons)*	*(thous head)*	*(thous head)*	*(thous head)*	*(thous head)*	*(thous tons)*	*(thous tons)*	*(thous tons)*	*(thous tons)*	*(thous tons)*	*(thous tons)*	*(thous tons)*	*(thous tons)*
1976	14708.5	10296.0	412.1	914.4	2034.4	1936.8	10439.5	1223.4	1004.8	220.9	1225.7	11.6	333.5	996.4
1977	14880.8	10416.6	445.1	950.0	2590.9	2172.4	11709.1	1247.7	1019.2	247.6	1266.9	11.8	351.8	1031.1
1978	15866.9	11106.8	460.3	931.1	2506.8	2143.4	11553.1	1322.3	1057.9	282.6	1340.5	11.7	320.5	1081.8
1979	16714.9	11700.4	465.2	911.6	2705.1	2188.3	11795.1	1389.7	1076.7	229.1	1305.9	11.6	359.9	1062.3
1980	17722.7	12405.9	499.3	943.1	3262.4	2421.1	13049.8	1478.2	1162.7	115.0	1277.6	12.1	389.3	1046.0
1981	18203.5	12742.5	528.0	1024.8	3652.5	2648.6	14275.7	1525.9	1203.1	133.5	1336.7	11.8	389.7	1091.2
1982	18376.9	12863.8	566.1	1265.5	3763.0	2960.5	15957.1	1553.8	1222.6	160.3	1382.8	11.8	371.0	1123.1
1983	18752.5	13126.8	601.9	1267.7	3995.4	3068.2	16537.7	1587.8	1230.4	228.4	1458.7	11.7	409.3	1187.9
1984	19063.8	13344.7	633.1	1409.0	4263.9	3321.3	17901.6	1623.7	1244.1	229.9	1474.0	11.8	427.5	1202.9
1985	19449.3	13614.5	655.0	1504.3	4402.7	3480.1	18757.8	1660.8	1272.7	235.5	1508.2	8.2	448.8	1232.5
1986	19647.9	13753.5	671.3	1603.4	4315.5	3569.4	19238.8	1680.3	1291.8	324.4	1616.2	6.2	446.8	1314.6
1987	20073.8	14051.7	691.6	1700.3	4382.5	3706.7	19978.8	1719.5	1316.0	256.9	1572.8	6.9	474.4	1286.5
1988	20492.7	14344.9	702.9	1755.0	4155.4	3704.5	19967.4	1751.7	1355.1	364.0	1719.1	7.5	521.1	1406.5
1989	20710.4	14497.3	697.7	1749.3	4403.4	3768.0	20309.6	1771.4	1402.3	339.9	1742.2	15.9	585.0	1436.0
1990	20865.9	14606.1	643.4	1662.5	4241.9	3578.5	19288.0	1774.5	1422.4	345.8	1768.2	16.1	621.4	1462.3
1991	21438.4	15006.9	609.9	1167.8	4268.1	3058.1	16483.3	1794.2	1412.5	482.1	1894.6	16.2	689.4	1571.0
1992	22045.3	15431.7	563.6	1672.4	5320.1	3832.0	20654.6	1877.2	1481.3	592.6	2073.9	16.4	659.3	1702.7
1993	22612.9	15829.0	546.7	1712.6	5528.3	3917.8	21116.9	1924.9	1479.7	714.4	2194.0	16.6	663.1	1795.1
1994	23111.9	16178.3	546.7	1753.8	5744.6	4023.9	21688.6	1968.3	1456.5	874.7	2331.2	16.8	736.7	1913.1

Table DA.9 The time-series data for constructing the capital input in Vietnam, the north and south (1976-94)

Year	VIETNAM					THE NORTH					THE SOUTH				
	Draught animals		Total horsepower of draught animals	Capacity of machines	Total capacity of tractors	Draught animals		Total horsepower of draught animals	Capacity of machines	Total capacity of tractors	Draught animals		Total horsepower of draught animals	Capacity of machines	Total capacity of tractors
	Draught buffaloes	Draught cattle				Draught buffaloes	Draught cattle				Draught buffaloes	Draught cattle			
	(thous head)	*(thous head)*	*(ten thous horsepower)*	*(ten thous horsepower)*	*(ten thous horsepower)*	*(thousand head)*	*(thousand head)*	*(ten thous horsepower)*	*(ten thous horsepower)*	*(ten thous horsepower)*	*(thousand head)*	*(thousand head)*	*(ten thous horsepower)*	*(ten thous horsepower)*	*(ten thous horsepower)*
1976	1542.0	682.2	119.2	117.6	236.7	1300.3	302.3	85.9	58.8	144.6	241.7	379.9	33.30	58.8	92.1
1977	1569.3	710.4	122.1	121.7	243.8	1294.0	294.4	85.1	60.9	146.0	275.3	416.0	37.03	60.9	97.9
1978	1570.2	689.1	121.0	116.9	237.9	1297.5	286.9	84.9	58.4	143.3	272.7	402.2	36.16	58.4	94.6
1979	1553.8	715.3	121.6	123.7	245.2	1262.4	287.4	83.0	61.8	144.9	291.4	427.9	38.53	61.8	100.4
1980	1563.1	736.7	123.2	140.5	263.7	1257.3	291.0	82.9	70.2	153.2	305.8	445.7	40.26	70.2	110.5
1981	1629.8	764.4	128.3	152.9	281.2	1309.7	323.3	87.5	61.2	148.6	320.1	441.1	40.78	91.7	132.5
1982	1676.3	810.4	133.2	141.5	274.7	1330.9	354.9	90.3	56.6	146.9	345.4	455.5	42.91	84.9	127.8
1983	1718.5	889.7	139.7	133.4	273.2	1358.2	412.2	94.8	53.4	148.2	360.3	477.5	44.88	80.1	124.9
1984	1736.1	930.3	142.8	138.0	280.8	1364.8	428.7	96.1	55.2	151.3	371.3	501.6	46.76	82.8	129.6
1985	1734.0	1006.8	146.8	140.8	287.7	1350.5	469.7	97.5	56.3	153.8	383.5	537.1	49.32	84.5	133.8
1986	1793.5	1065.0	153.1	161.0	314.2	1396.5	503.4	101.8	64.4	166.2	397.0	561.6	51.35	96.6	148.0
1987	1868.4	1186.3	163.6	128.5	292.1	1457.5	556.1	107.9	51.4	159.3	410.9	630.2	55.77	77.1	132.8
1988	1913.1	1261.8	170.1	128.5	298.6	1491.6	622.0	113.2	51.4	164.6	421.5	639.8	56.86	77.1	134.0
1989	1946.1	1361.1	177.2	121.9	299.1	1532.8	717.2	120.5	36.6	157.1	413.3	643.9	56.64	85.3	142.0
1990	1938.5	1420.8	181.2	115.3	296.5	1554.1	756.7	123.8	34.6	158.4	384.4	664.1	57.35	80.7	138.1
1991	1944.0	1307.5	189.2	161.5	350.7	1585.3	841.2	125.4	48.4	173.9	358.7	466.4	63.79	113.0	176.8
1992	1962.8	1335.2	192.0	226.1	418.1	1637.6	891.2	130.4	67.8	198.2	325.2	443.9	61.65	158.3	219.9
1993	2013.3	1361.5	198.3	316.5	514.8	1658.4	945.4	132.6	95.0	227.6	354.9	416.1	65.65	221.6	287.2
1994	2044.1	1417.9	202.4	359.8	562.2	1658.4	1002.1	140.7	107.9	248.6	385.7	415.8	61.75	251.8	313.6

DA.3 Time- series data of the composite price between output and factor inputs $\beta p(1-C_0m)$ in 1976-94

Combined with the data set in Section DA.1, the following data are used for the analysis of the effects of internal and external trade liberalisation (Chapter 7), the dynamic transitional path and long-run growth for rice production (Chapter 8). Corresponding to Section DA.1, the duration of time-series data also range from the years 1976 to 1994.

As analysed in Section 4.1 (Chapter 4), the index of the composite price between output and factor inputs, or $\beta p(1-C_0m)$, reflects the changes in the structure (between inputs and outputs) and price level under the effects of trade liberalisation. Relying on the theoretical and empirical analyses conducted earlier, this section documents the data sources and the adjustments use to generate this composite price index from two time-series data sets: the average goods price (βp) and the value of $(1-C_0m)$ in terms of the average cost share parameter (m).

(a) The time-series data for the average rice price βp

Returning to the average goods price (βp) given in equation (3.6) and renumbering it here for convenience, gives

$$\beta p = (\beta_0 p_s + \beta_1 p_M + \beta_2 p_W). \tag{DA.4}$$

The time-series data of the *nominal* rice price in years 1976-94 is available from the State Department of Price (SDP). Of course, the nominal rice price is not the *average* nominal rice price (βp^N) and is more different from *the average real* rice price (βp), as used in the theoretical framework in the chapters above. To obtain the time-series data for the average real rice price βp, the data for the nominal average rice price (βp^N) needs to be constructed.

In the stage of the opening up of markets, where there is freedom to purchase and sell at a common market price and the barriers to market entry are removed (see Section 1.1 in Chapter 1 above for more detail), the market (nominal) price for rice captures all of the components of equation (DA.3), and hence it is the actual nominal value for βp^N. However, Vietnam experienced periods of multiple rice prices (for example, a state rice price, a free domestic market rice price, etc.), each determined separately in their own market. Consequently, the time-series index of the market share (β) in the periods of multiple prices and markets needs to be determined. For our purposes, in the period of the communal system, the market share of the state market (β_0^C) is equal to one and the market share of the domestic (β_1^C) and international markets (β_2^C) is zero. In the output contract system, there were parallel markets with the market share set at 0.8, 0.2 and 0 for the state market (β_0^D), domestic market (β_1^D) and international market (β_2^D) respectively.[14] Substituting the value of market share (β) into (DA.4), the data for the nominal average rice price (βp) for Vietnam, the north and south respectively are obtained (see Table DA.10).

It is easy to see in Table DA.10 that the average nominal rice price (βp^N) has experienced extreme fluctuation. It jumped by a factor of 5400 to 6000 from 1976 to 1994 (or from 0.4 to 2146.60 Dong[15] per kilogram in the north and from 0.3 to 2012.50

[14] This is average data which was computed from the GSO (various years) in which the market share is 0.88, 0.12 (in 1986), 0.82, 0.18 (in 1987) and 0.82, 0.18 (in 1988) for the state and domestic markets for food grains respectively. The research by the State Planning Committee used the same rate (0.8 and 0.2) to adjust the multiple or various prices for grain at this time.
[15] The Vietnamese currency

Dong per kilogram in the south, see Table DA.13). The fluctuation of the average nominal rice price was affected by an extremely high inflation rate (at the three digit level in 1987-88), some few short-run shocks (Nguyen D Chuc, 1995) and several large changes in the nominal value of the currency (such as in the years 1977 and 1985) where the nominal value of the currency differed largely. For example, in 1985 one Dong in terms of the new currency was equivalent to ten Dong in terms of the old currency.

Normally, the average real rice price βp can be obtained by adjusting the average nominal rice price βp according to the inflation rate. In this case, is impossible to do so directly because of the serious problems with the inflation rate data. (Clearly the problems with data reliability for the Vietnamese economy are not a new issue and certainly one that is impossible to deny.[16]) In our case those problems are: (a) the reported measures of the inflation rate data are inconsistent even though they stem from one source, the General Statistics Office (GSO)[17]; (b) until the episode of three digit rates of inflation (the period 1987-88), the Vietnamese authorities still perceived inflation as a 'capitalist' phenomenon, so that the measurement of inflation generated virtually no interest and as a result was poorly constructed; (c) a high and fluctuating inflation rate in the period 1986-89 caused measurement difficulties at that time[18]; and

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[16] Many economists have already complained about the reliability of inflation rate data in Vietnam. For example, McCarty, Paunlagui and Vu (1993) give an example of the differences in the annual inflation rate from the sources of the World Bank, the GSO and the International Monetary Fund (IMF) although all of those data supposedly came from one original source, the GSO.

[17] I collected three different time-series data sources for the annual inflation rate (general retail price index). Despite that, all of them come from the GSO, and surprisingly all of them differ markedly from each other. For example according to the GSO (various years) the reported annual inflation rate (as a per cent change from the previous year) is 487.3, 301.3, 308.2 74.3 (by the report by the GSO, 1993) and 874.7, 323.1, 493.8, 134.7, 167.6 and 117.6 (GSO, 1994) for 1986, 1997, 1988, 1989, 1990, 1991 and 1992 respectively.

[18] This applies to all three data sources for the inflation rate (mentioned above), and if we use any of them directly we can obtain unrealistic results, e g the rice price in a given year can be greater than the previous year by about 800 per cent, even though there was no obvious price shock to explain such a difference!

(d) before 1989, the basket of goods for calculating the rate of inflation and the Gross Domestic Product deflator was based on only nine consumption goods in urban areas so that it could obviously not represent anything like a representative basket of goods for the whole economy.[19] Indeed, until 1989 a subsidised price for those goods was achieved through a coupon system, with extremely cheap prices (almost free or given away) in urban areas relative to the rest of the country. Nevertheless, farmers paid for their consumption goods at the free market price so that the inflation rate (before 1989) reflected mostly just the change in regime from the state determined urban price to the free market price, rather than the prices farmers actually paid or received over time.[20]

Thus, because of these problems it is not possible (as mentioned) to construct the real value of average rice price (βp) using a standard inflation rate adjustment. Instead, we measure the real value of the average rice price (βp) in terms of an independent value standard such as gold or the value of the U.S. dollar (US$). Indeed, in doing so we are following a similar approach to that used by the Vietnamese people themselves, (especially during periods of hyperinflation) who commonly measure their durable goods, assets and even rice prices in terms of gold or the value of the US$.[21] Besides, in practical terms, since many expenditures on factor inputs are already measured in terms of US$ (e.g., data in the SRF), I chose to determine the real value of the average rice price (βp) in terms of U.S. dollars. Moreover, given the arguments regarding a strong correlation between the inflation rate, the price of gold and the price of the US$ (study

[19] Based on the reports by the 'Action Group Against Inflation of the Vietnamese Government' in 1987-1990.

[20] The government had attempted several times to cancel the heavy subsidy for consumer goods (through coupons in the state sector) such as unsuccessful 'price, wage and money' reform in 1985, and later the successful reforms undertaken in 1990.

[21] This phenomenon is not unusual in the LDC's which experience hyperinflations, such as in Latin America (see Canto and Nickelsburg, 1987).

by the 'Action Group Against Inflation of the Vietnamese Government'), and a high correlation between inflation rate, the price of the US$ and the exchange rate in Vietnam (World Bank, 1994a, p.67-68) this is the best and most reasonable alternative.

The time-series data for the average rice price (βp) in terms of US$ is indicated in Table DA.13 where the data sources for the exchange rate in the period 1976-94 are provided from the State Department of Price (SDP) and the State Bank of Vietnam (SBV).[22]

During the various stages of trade liberalisation, the exchange rate went from a controlled and overvalued exchange rate to multiple exchange rates and eventually to a devaluated and unified exchange rate. In the period 1976-1985, the official exchange rate was the only rate available and was regulated by the State at an overvalued level (see Table DA.10, column 3). During the period 1985-89, multiple exchange rates, which means a state exchange rate (regulated by SBV) and a parallel market exchange rate, had operated at one in the same time in the market, and at the very different values.[23] Similar to the approach for adjusting the average nominal rice price above (see equation (DA.3)), here the average exchange rate is defined as a sum of the state exchange rate multiplied by the state market share, and the market exchange rate multiplied by the free market share. The average exchange rate in the period 1985-89 is thus obtained (see Table DA.10, column 3).[24] From 1989 until now, exchange rate

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[22] It should be noted that there is the fluctuations in the world price for agricultural goods (Deaton and Laroque, 1992)

[23] In fact, in this period three official dollar exchange rate existed at one time: Dong 18: US$ 1 to Dong 900 US$ for the external trade rate, Dong 18: 1 US$ to Dong 3000: 1 US$ for inward remittances by Vietnamese living abroad and Dong 15: US$ 1 to Dong 3000 US$ for non-commercial transactions such as tourism, remittances or for foreigners (see Nguyen V Thanh, (1996)).

[24] Based on data by the GSO, in the period 1985-89 for the goods market, the share was 0.8 and 0.2 for the state market and free market respectively. It is firmly assumed that the share between state and free market for foreign exchange is the same rate so it is 0.8 and 0.2 for the state market and free market respectively. According to the SBV, the official exchange rate was 15 Dong (1985), 80 Dong (1986), 368

reform was successful in the unification and devaluation of multiple exchange rates, hence we can safely use the market exchange rate or the exchange rate of the SBV to represent the exchange rate during this time (see Table DA.10, column 3).

We take the nominal rice price in Nam Dinh and Can Tho to present the rice price in the north and south respectively (following the practice of the State Department of Price, or SDP), and, based on our adjustments, the time series of the average real rice price in the north and south (1976-94) are constructed (see Table DA10, columns 5 and 6,). To compute the average real rice price for Vietnam, we assume that the affect of the rice price in the south (or the north) on the average rice price in Vietnam depends on the share of the south (or the north) in the total rice output of Vietnam. Therefore, the weighted ratio of rice price for the south (or the north) is defined as the ratio between rice output in the north (or the south) divided by the total output of rice in Vietnam (see Table DA.11). Thus the average real rice price for Vietnam can be defined as

$$p^{VN} = Ratio^{N} p^{N} + Ratio^{S} p^{S} \tag{DA.5}$$

where $Ratio^N$, p^N, $Ratio^N$, and p^N represent the weighted ratio and the average real rice price in the north and south respectively, with $Ratio^{N} + Ratio^{S} = 1$ (see Table DA.10, column 4). Consequently, taking the numeric mean of βp in the period of communal system as a base, the growth of βp is showed in Table DA.10, columns 7, 8 and 9 for Vietnam, the north and south respectively.

Dong (1987) and 3000 Dong (in 1988), while the free market exchange rate was 115 Dong (1985), 425 Dong (1986), 1270 Dong (1987) and 5000 Dong (1988).

(b) The time-series data for the average cost share parameter (m)

This data set is used to generate the time-series data of ($1-C_0m$), as a component in the composite price index between inputs and output. The value of C_0 is computed from equation (3.8) and given as 1.4 for the case of rice production in Vietnam (see Appendix F). However, the value of average weighted cost share parameter *(m)* varies over time and is yet unknown.[25]

The value of m is defined from formulas given by equations (3.9) and (3.13), where $\alpha_1=0.4$; $\alpha_2=0.3$; $\alpha_3=0.2$ and $\alpha_4=0.1$ (see Appendix 7A). so that m is given as

$$m=\frac{W(w_i)}{\beta p}=\frac{(w_1)^{0.4}(w_2)^{0.3}(w_3)^{0.2}(w_4)^{0.1}}{\beta p} \qquad \text{(DA.6)}$$

where w_1,w_2, w_3 and w_4 are the price of labour, land, current input and capital respectively.

For simplification and to minimise the errors involved in adjusting the nominal value to the real value of the average weighted cost share parameter (m), I measure the input price (w_i) in terms of rice units (w_i^{RE}), such as how many tons of rice farmers have to pay to get one ton of urea to employ one thousand man-day works, or to rent one hectare of rice-producing land etc.[26] In any case, some data sources for factor input expenditures are already measured in terms of rice units as a matter of practice. Thus equation (DA.6) can be rewritten as

$$m=\frac{W(w_i)}{\beta p}=\frac{(w_1^{RE}\beta p)^{0.4}(w_2^{RE}\beta p)^{0.3}(w_3^{RE}\beta p)^{0.2}(w_4^{RE}\beta p)^{0.1}}{\beta p}$$

[25] To make our work become more simple, I construct m for whole of country, and assume this value also applies to the north and south.

[26] This approach is common in Vietnam and even more popular in the episodes of high inflation when farmers not only bartered rice for factor inputs but also accounted for costs and benefits in terms of rice measurements.

or

$$m = (w_1^{RE})^{0.4}(w_2^{RE})^{0.3}(w_3^{RE})^{0.2}(w_4^{RE})^{0.1} \tag{DA.7}$$

where w_1^{Re} ;w_2^{Re} ;w_3^{Re} and w_4^{Re} are the ratio of expenditure (called the relative input price) of labour, land, current input and capital in terms of rice unit respectively.

Chapters 3 and 4 above referred to the average factor price $W(w_i)$ as an explicit payment that farmers actually have to expend. In the case of Vietnam the most important part of that that explicit payment has been the expenditure on current input (Nguyen T Khiem, 1995 and UNDP-FAO,1989). The facts in Vietnam show that the market for current inputs developed more rapidly and significantly in comparison to that for land and labour. Therefore, to make the calculation of m more simple, we pay the most attention to calculation of w_3^{Re} in every year. In other words, assume that w_1^{Re} and w_2^{Re} do not change much, that is, while the price for rice becomes more expensive, the labour cost and land rent cost also becomes expensive, those prices rising at similar rates. Because capital plays a small share in rice production (a value 0.1), for simplification ,we also assume that the relative price of capital (w_4^{Re}) can be ignored.

By the definition of total current input (see Section DA.1) all the various items of current inputs are able to be converted into the standard nutritional content of fertiliser. Since the cost for chemical fertiliser takes on a major part in the cost for current inputs (see Nguyen T Khiem, (1995)), the relative price of chemical fertiliser or the relative urea/rice price can nicely be used to represent the relative price of current inputs (w_3^{Re}). The time-series data of the relative urea/rice price (GSO, and the CPC) during the period 1976-94 are indicated in Table DA.12 and come from the Central Price Committee (CPC), as quoted in Nguyen T Hien (1991) and Nguyen T Khiem, (1995). It is noted that, the relative price in question was the free market price or barter exchange ratio between the State and farmer rather than the state price of urea, which was issued by the CPC[27]. Since Vietnam is a heavy importer of chemical fertiliser, after the opening up of markets the urea/rice price ratio in Vietnam quickly decreased and converged to the world price ratio level[28].

The relative price of labour to rice output or the ratio between labour cost to one unit of rice (w_1^{Re}) is defined as

$$w_1^{\mathrm{Re}} = \frac{w_1^A N^A}{R^A p} \qquad \text{(DA.8)}$$

where w_1^A, N^A, R_1^A and p are the average wage for one man-work day, the average number of man-work days per one cultivated hectare, the yield per one cultivated hectare (ton/hectare) and the rice price respectively. Table S.3 in the Sub-Appendix shows the data (SRF) and the results for calculating the relative price of labour cost per one ton of rice output for the north (0.15) and the south (0.25). The approximate average relative price of labour per one ton of rice output for Vietnam is taken as 0.2.

The relative price between land cost to output w_2^{Re}, is calculated as

$$w_2^{\mathrm{Re}} = \frac{T^A}{R_S{}^A} \qquad \text{(DA.9)}$$

where T^A and R^A are the average tax levies per one sown hectare in terms of quantity of rice and the average yield of rice per one sown hectare respectively. The values of T^A and R^A are computed approximately from the data provided by the GSO and the SPC

[27] Before 1980, the State decided that the relative urea/rice price was 1.0, but the equivalent amount of fertiliser in these terms was small and farmers had instead to pay a urea/rice price ratio of 2.0 to 3.0 (SDP, 1995a). Because there were a good deal of 'intermediate organisations' at least 20 per cent of the chemical fertiliser which was 'lost' from the state network and subsequently became available at a high price to farmers (UNDP-FAO, 1989).

[28] The world relative urea/rice price was 0.62 (1986), 0.53 (1987), 0.58 (1988), 0.45 (1989), 0.64 (1990), 0.8 (1991) and 0.78 (1992) (CPC and GSO, various years).

(1990) with T^A being roughly 0.3 ton/hectare and R^A about 3 ton/hectare. As a result w_2^{Re} is computed to be roughly the value 0.1. From equation (DA.6), the average cost share parameter (m) is thus calculated as

$$m = (0.2)^{0.3}(0.1)^{0.4}(w_3^{\mathrm{Re}})^{0.3} \qquad \text{(DA.10)}$$

where the value of w_3^{Re} is as indicated in Table DA.12. Since the time series of m is determined, the time series of $(1\text{-}C_0 m)$ is easily obtained and indicated in Table DA.12.

Table DA.10 **The time-series data for constructing the average rice price (1976-94)**

	The nominal average price (βp^N) (Dong/ Kg)		The exchange rate	The average rice price (US$/ton)			The growth rate of the average rice price		
	The north	**The south**		**VIETNAM**	**The north**	**The south**	**VIETNAM**	**The north**	**The south**
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
1976	0.40	0.30	4.21	82.22	95.01	71.26	with average price for this period of 77.74 US$	with average price for this period of 84.63 US$	with average price for this period of 72.04 US$
1977	0.39	0.30	4.21	80.18	91.62	71.26			
1978	0.57	0.47	8.00	64.99	71.43	58.93			
1979	0.74	0.71	9.00	80.73	82.54	79.37			
1980	0.74	0.71	9.00	80.56	82.54	79.37			
1981	3.50	3.57	40.00	88.51	87.50	89.29	13.85	3.39	23.94
1982	3.86	3.87	42.00	91.99	91.84	92.11	18.33	8.52	27.86
1983	4.47	4.13	45.00	94.87	99.30	91.68	22.04	17.34	27.27
1984	4.98	4.81	50.00	97.60	99.66	96.23	25.55	17.76	33.58
1985	5.71	5.00	56.00	94.34	102.04	89.29	21.35	20.57	23.94
1986	21.43	17.14	190.00	99.05	112.78	90.23	27.42	33.26	25.24
1987	100.00	85.71	900.00	101.62	111.11	95.24	30.72	31.29	32.20
1988	514.29	357.00	3400.00	123.26	151.26	105.00	58.55	78.73	45.75
1989	602.08	520.00	4000.00	137.86	150.52	130.00	77.33	77.86	80.46
1990	912.46	835.83	5575.00	151.04	163.67	143.87	94.29	93.39	99.71
1991	2070.00	1741.67	11500.00	180.91	180.00	181.34	132.72	112.69	151.72
1992	1898.05	1804.17	11000.00	164.89	172.55	160.48	112.10	103.89	122.77
1993	1611.20	1795.83	10000.00	165.67	161.12	168.61	113.10	90.38	134.05
1994	2146.60	2012.50	10000.00	197.29	214.66	186.34	153.79	153.65	158.66

Note: *(i)Since 1990, the price in term of US$ is provided from the CPC for the north and south; (ii) the price in 1991 in the north is measured in the normal situation rather than the short run shock of high prices; (iii) in the period of the dual price system (1981-88), the rice price is mainly taken as the 'negotiated price', and calculated from the market share between the State and free market at their price level.*

Table DA.11 **The time-series of weighted ratio of rice price for the north and south**

	Total output of Vietnam	Output of rice in the north	Ratio of weighted rate for the north (equals (1)/(2))	Ratio of weighted rate for the south (equals 1-(3))
	1	*2*	*3*	*4*
1976	11827.2	5457.7	0.46	0.54
1977	10597.1	4645.9	0.44	0.56
1978	9789.9	4749.6	0.49	0.51
1979	11362.9	4878.7	0.43	0.57
1980	11647.4	4371.4	0.38	0.62
1981	12415.2	5401.1	0.44	0.56
1982	14390.2	6170.5	0.43	0.57
1983	14743.3	6174.1	0.42	0.58
1984	15505.6	6200.0	0.40	0.60
1985	15874.8	6292.0	0.40	0.60
1986	16002.9	6262.8	0.39	0.61
1987	15102.6	6075.2	0.40	0.60
1988	17000.0	6708.7	0.39	0.61
1989	18996.3	7275.4	0.38	0.62
1990	19225.2	6962.4	0.36	0.64
1991	19621.9	6257.5	0.32	0.68
1992	21590.3	7885.1	0.37	0.63
1993	22836.6	8973.3	0.39	0.61
1994	23528.3	9100.0	0.39	0.61

Table DA.12 **The time-series of the average cost share parameter *(m)* and (*1-C_0m*) (1976-94)**

Year	Relative price between urea and rice	The average rice price	Urea price	The total component of relative price between urea and rice	The average weighted cost share parameter	The value of (1-*C(0)m*)
	(w_3^{RE})	(US$)/ton	(US$)/ton	$(w_3^{Re})^{0.3}$	m	
1976-80)	3.0	90.5	271.5	1.39	0.31	0.56
1981	3.0	113.6	340.9	1.39	0.31	0.56
1982	3.0	122.9	368.8	1.39	0.31	0.56
1983	3.0	129.9	389.8	1.39	0.31	0.56
1984	3.0	131.4	394.2	1.39	0.31	0.56
1985	2.2	136.3	305.4	1.27	0.28	0.60
1986	2.2	133.4	298.9	1.27	0.28	0.60
1987	2.0	136.5	273.0	1.23	0.28	0.61
1988	2.0	131.1	262.2	1.23	0.28	0.61
1989	1.6	137.9	224.7	1.15	0.26	0.64
1990	1.5	151.0	228.1	1.13	0.25	0.65
1991	1.0	185.1	190.6	1.00	0.22	0.69
1992	0.9	164.9	155.0	0.97	0.22	0.70
1993	1.0	165.7	165.7	1.00	0.22	0.69
1994	1.1	197.3	221.0	1.03	0.23	0.68

Sub-Appendix: SOME DATA DETAILS FOR RICE PRODUCTION IN VIETNAM

Table S.1: **The average chemical fertiliser use for rice production in the Red River Delta and Cuu Long River Delta** *(kg/ hectare)*

Place	1989			1990			1991			1992		
	Kind of fertiliser			Kind of fertiliser			Kind of fertiliser			Kind of fertiliser		
	Nitrogen (N)	Phosphate (P)	Potassium (K)	Nitrogen (N)	Phosphate (P)	Potassium (K)	Nitrogen (N)	Phosphate (P)	Potassium (K)	Nitrogen (N)	Phosphate (P)	Potassium (K)
The Red River Delta	na	na	na	76.67	16.67	53.33	90.35	20.83	2.63	159.00	1.82	4.22
The Cuu Long River Delta	109.45	58.58	4.90	112.82	50.78	7.18	104.55	43.04	3.98	131.83	53.949	7.18

Source: *The data is derived from the Survey of Rice Farmer (SRF) for 394, 335, and 313 rice farmers in the Red River Delta in 1990, 1991 and 1992 respectively and for 231, 170, 208 and 189 rice farmers in the Cuu Long River Delta in 1989, 1990, 1991 and 1992 respectively.*

Table S.2**: The average insecticide use for rice production in the Red River Delta and Cuu Long River Delta**

	RED RIVER DELTA			CUU LONG RIVER DELTA			Average weighted ratio insecticide between the north over the whole country	Average weighted ratio insecticide between the south over the whole country
	Expenditures *(Dong/hectare)*	Expenditures *(US$/hectare)*	Average amount use *(kg/hectare)*	Expenditures *(Dong/hectare)*	Expenditures *(US$/hectare)*	Average amount use *(kg/hectare)*		
1989	na	na	na	35 900	3.26	2.97		
1990	53 562	4.87	1.43	58 209	5.29	4.81	0.48	0.52
1991	114 439	10.4	5.69	144 000	13.09	11.9	0.44	0.56
1992	141 288	12.84	5.84	177 000	16.09	14.63	0.44	0.56
Average	77 332	7.03	3.24	103 777	9.43	8.58	0.45	0.55

Source: *The same as in Table S.1*

Table S.3: The relative price between labour cost and output in the Red River Delta and Cuu Long River Delta

	RED RIVER DELTA									CUU LONG RIVER DELTA								
	The cost, in terms of (US$)				Average cost per day (US$)	Total labour cost per hectare (US$)	Yield of rice (ton/ hectare)	Output per hectare (US$)	Ratio wage/ output	The cost, in terms of (US$)				Average cost per day	Total labour cost per hectare (US$)	Yield of rice (ton/ hectare)	Output per hectare (US$)	Ratio wage/ output
	Land preparation	Trans-planting	Weed-ding	Harver-ting						Land preparation	Trans-planting	Wee-ding	Harver-ting					
1989	na	na	na	na	na	na	2.63	395.87	na	1.4	0.9	0.75	1	1.01	60.8	3.44	447.2	0.14
1990	0.43	0.38	0.33	0.5	0.41	98.4	2.73	412.34	0.24	1.5	0.97	0.8	1.07	1.09	65.1	3.46	479.79	0.13
1991	0.59	0.49	0.45	0.54	0.5175	124.2	2.93	542.22	0.23	1.28	0.82	0.69	0.92	0.93	55.7	3.52	638.32	0.09
1992	0.61	0.51	0.46	0.51	0.5225	125.4	2.8	461.69	0.27	1.98	1.27	1.06	1.42	1.43	86.0	3.46	555.26	0.15
1993	0.71	0.67	0.57	0.62	0.6425	154.2	2.49	412.51	0.37	2.09	1.35	1.12	1.5	1.52	90.9	3.48	586.76	0.16
1994	0.91	0.73	0.64	0.82	0.775	186.0	3.12	615.56	0.30	2.55	1.64	1.36	1.82	1.84	110.6	3.74	696.90	0.16

Source: *The same as in Table S.1.*

*(**Note**: The average of labour expenditure(in terms of US$) for producing 1 US$ of output are 0.25 and 0.15 for the north and south respectively.*

Take the average ratio as 0.2 for the whole country.)

Table S.4 **Monthly rice price in the Red River Delta and the Cuu Long River Delta in 1989-95** *(Dong/ kg)*

	January	February	March	April	May	Jun	July	August	September	October	November	December
1989												
In the RRD	700	850	660	630	660	650	550	505	500	500	480	540
In the CRD	460	480	550	560	530	480	500	500	560	560	540	520
1990												
In the RRD	670	680	750	840	900	700	800	800	800	900	1300	1900
In the CRD	520	520	540	540	540	800	950	900	1000	1070	1300	1350
1991												
In the RRD	2100	2100	2200	2200	2500	2100	2300	2300	2150	2000	2050	2400
In CRD	1500	1700	1700	1600	1550	1550	1750	1700	1700	1900	2150	2100
1992												
In the RRD	2450	2400	2300	2200	2250	1900	1850	1700	1500	1500	1750	1650
In the CRD	2000	2000	1900	1800	1800	1750	1800	1700	1700	1700	1700	1800
1993												
In the RRD	1800	1750	1900	2000	2000	1600	1600	1650	1600	1600	1600	1800
In the CRD	1800	1700	1700	1700	1800	1800	1700	1900	1900	1700	1900	1950
1994												
In the RRD	1950	2000	2200	2200	2320	2200	1900	2000	2450	2800	2800	3000
In the CRD	2050	2300	2000	1900	1800	1800	1800	1800	1800	2100	2200	2200

Source: *The State Department of Price (SDP)*

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